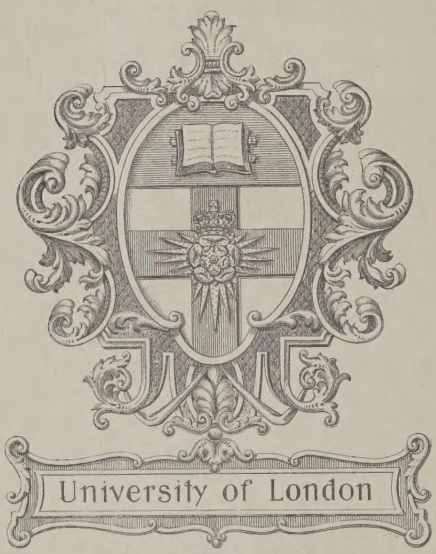
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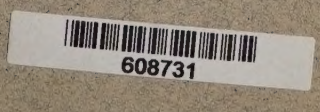
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# REPORTS

FROM

# COMMISSIONERS, INSPECTORS,

AND OTHERS:

*THIRTY VOLUMES.*

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—*(25.)*—

METROPOLITAN SEWAGE DISCHARGE.

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Session

5 *February* —— 14 *August* 1884.

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VOL. XLI.

1884.

# REPORTS

FROM

# COMMISSIONERS, INSPECTORS,

AND OTHERS:

1884.

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*THIRTY VOLUMES:—CONTENTS OF THE*

TWENTY-FIFTH VOLUME.

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N.B.—*THE* Figures *at the* beginning of the line, *correspond with the* N° *at the foot of each* Report; *and the* Figures *at the* end of the line, *refer to the* MS. Paging *of the Volumes arranged for The House of Commons.*

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METROPOLITAN SEWAGE DISCHARGE:

[c. 3842.] First Report of the Commissioners appointed for the purpose of inquiring into the effects of the Discharge of the Sewage of the Metropolis into the River Thames - - - - - p. 1

[3842-I.] Minutes of Evidence taken before the Commission from July 1882 to July 1883, together with a Selection from the Appendices, and a Digest of the Evidence - - - - - - - 69

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# ROYAL COMMISSION ON METROPOLITAN SEWAGE DISCHARGE.

# FIRST REPORT

OF

# THE COMMISSIONERS.

**Presented to both Houses of Parliament by Command of Her Majesty.**

LONDON:
PRINTED BY EYRE AND SPOTTISWOODE.

To be purchased, either directly or through any Bookseller, from any of the following Agents, viz.,
Messrs. HANSARD and SON, 13, Great Queen Street, W.C., and 32, Abingdon Street, Westminster;
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1884.

[C.—3842.] *Price 9d.*

# ORIGINAL COMMISSION.

*VICTORIA, R.*

**Victoria,** by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, to Our right trusty and well-beloved Councillor George William Wilshere, Baron Bramwell; Our trusty and well-beloved Sir John Coode, Knight, Member of the Council of the Institution of Civil Engineers; Our trusty and well-beloved Alexander William Williamson, Esq., Doctor of Laws, Doctor of Philosophy, Fellow of the Royal Society, Professor of Chemistry in the University College, London; Our trusty and well-beloved Francis Stephen Bennet François de Chaumont, Esq., Retired Surgeon-Major in Our Army, Doctor of Medicine, Fellow of the Royal Society; Our trusty and well-beloved Thomas Stevenson, Esq., Doctor of Medicine; and Our trusty and well-beloved James Abernethy, Esq., Fellow of the Royal Society of Edinburgh, Member of the Institution of Civil Engineers, Greeting:

**Whereas** We have deemed it expedient that a Commission should forthwith issue to inquire into and report upon the system under which sewage is discharged into the Thames by the Metropolitan Board of Works, whether any evil effects result therefrom, and in that case what measures can be applied for remedying or preventing the same:

**Now know ye** that We, reposing great trust and confidence in your knowledge and ability, have authorised and appointed, and do by these presents authorise and appoint, you, the said George William Wilshere, Baron Bramwell, Sir John Coode, Alexander William Williamson, Francis Stephen Bennet François de Chaumont, Thomas Stevenson, and James Abernethy, to be Our Commissioners for the purposes aforesaid.

**And** for the better effecting the purposes of this Our Commission, We do by these presents give and grant unto you, or any three or more of you, full power to call before you such persons as you shall judge likely to afford you any information upon the subject of this Our Commission; and also to call for, have access to, and examine all such books, documents, registers, and records, as may afford you the fullest information on the subject, and to inquire of and concerning the premises by all other lawful ways and means whatsoever.

**And** We do further by these presents authorise and empower you, or any three or more of you, to visit and personally inspect such places as you may deem expedient for the more effectual carrying out of the purposes aforesaid.

**And** We do by these presents will and ordain that this Our Commission shall continue in full force and virtue, and that you, Our said Commissioners, or any three or more of you, may from time to time proceed in the execution thereof and of every matter and thing therein contained, although the same be not continued from time to time by adjournment.

**And** We further ordain that you, or any three or more of you, may have liberty to report your proceedings under this Our Commission, from time to time, if you shall judge it expedient so to do.

And Our further will and pleasure is, that you do, with as little delay as possible, report to Us, under your hands and seals, or under the hands and seals of any three or more of you, your opinion upon the several matters herein submitted for your consideration.

And for the purpose of aiding you in such matters We hereby appoint Our trusty and well-beloved William Pole, Esq., Fellow of the Royal Society and Fellow of the Royal Society of Edinburgh, Member of the Council of the Institution of Civil Engineers, to be Secretary to this Our Commission.

Given at Our Court at Saint James's, the twenty-second day of June, one thousand eight hundred and eighty-two, in the forty-sixth year of Our reign.

By Her Majesty's Command,
W. V. Harcourt.

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## SUPPLEMENTARY COMMISSION.

*VICTORIA, R.*

Victoria, by the Grace of God of the United Kingdom of Great Britain and Ireland Queen, Defender of the Faith, to Our trusty and well-beloved Sir Peter Benson Maxwell, Knight; and Our trusty and well-beloved Charles Brisbane Ewart, Esquire, Companion of Our most Honourable Order of the Bath, a Colonel in Our Corps of Royal Engineers, Greeting:

Whereas We did by Warrant under Our Royal Sign Manual, bearing date the twenty-second day of June, one thousand eight hundred and eighty-two, appoint Our right trusty and well-beloved Councillor William Wilshere, Baron Bramwell, together with the several gentlemen therein mentioned, or any three or more of them, to be Our Commissioners to inquire into and report upon the system under which sewage is discharged into the Thames by the Metropolitan Board of Works, whether any evil effects result therefrom, and in that case what measures can be applied for remedying or preventing the same.

Now know ye that We, reposing great trust and confidence in your zeal, discretion, and ability, have authorised and appointed, and do by these presents authorise and appoint, you, the said Sir Peter Benson Maxwell and Charles Brisbane Ewart, to be Our Commissioners for the purposes aforesaid in addition to and together with the Commissioners whom We have already appointed by the before-mentioned Royal Warrant.

Given at Our Court at Saint James's, the first day of November, one thousand eight hundred and eighty-two, in the forty-sixth year of Our reign.

By Her Majesty's Command,
W. V. Harcourt.

# CONTENTS OF THE FIRST REPORT.


PAR.

1. Introductory.
2. Three subjects of inquiry.
3. Limitation of the inquiry, in the first instance, to the first two of these.
4. General nature and conduct of the proceedings of the Commissioners. Parties appearing.
5. Divisions of the present Report.

PART I.

HISTORICAL NOTICE IN REGARD TO THE DRAINAGE OF LONDON.

EARLY HISTORY DOWN TO 1830.

6. The original object of sewers was only to carry away the rain water.
7. Early legislation in regard to them.
8. Introduction of water-closets; their connexion with the drains and sewers.

EARLY SCHEMES, 1830–1846.

9. Pollution of the Thames. John Martin's proposed plan of embankments and intercepting main sewers.
10. Other schemes.

COMMISSIONS OF SEWERS TO 1847.

11. The drainage of the metropolis was under the charge of eight local and independent Commissions.
12. Evils of divided management.

CONSOLIDATED COMMISSION, 1848 TO 1855.

13. Act of Consolidation.
14. Power and functions of the body.
15. First Commission.
16. Second Commission. Competitive designs for main drainage.
17. Third Commission. Appointment of Mr. Frank Forster as Engineer.
18. His plans for the main drainage.
19. Fourth Commission.
20. Fifth Commission. Bazalgette and Haywood's plans.
21. Suggestions of the Board of Health. Sixth Commission.
22. Abolition of cesspools. Foul state of the Thames.
23. Inefficiency of the Drainage Authority. Its supercession.

THE PLANS OF THE METROPOLITAN BOARD OF WORKS, 1856.

24. Power and duties of the Board.
25. First plan.
26. Its submission to the Commisssioners of Her Majesty's Works. Question as to position of outfalls.
27. Second Plan.
28. Third Plan. Reference by Government of the whole subject to three engineers.

THE INQUIRY OF THE GOVERNMENT REFEREES, 1857.

PAR.

29. Instructions.
30. Report.
31. Sewage and rainfall to be provided for.
32. Position of outfalls proposed by the Metropolitan Board.
33. Plan of the Referees.
34. Proposal to remove the outfalls lower down the river.
35. Main outfall channels.
36. Storm overflows.
37. Estimate of cost.
38. Possible utilization or deodorization of the sewage.
39. Conclusion.
40. Appendices.

DISCUSSIONS OF THE SUBJECT, 1857–8.

41. Objections to the Referees' scheme. Replies and rejoinders.
42. Submission of the subject, by the Metropolitan Board, to Messrs. Bidder, Hawksley, and Bazalgette.

REPORT OF MESSRS. BIDDER, HAWKSLEY, AND BAZALGETTE, 1858.

43. General contents.
44. Examination of Referees' report.
45. Sewage and rainfall; area to be drained; condition of river; internal drainage.
46. Position of outfalls.
47. Estimate of cost.
48. Conclusions.
49. Extracts from Appendices.
50. Answer by the Referees, and rejoinders.

STATE OF THE THAMES, 1858.

51. Statements in Parliament. Temporary remedial measures.

ALTERATION OF THE LAW AND CONSTRUCTION OF THE MAIN DRAINAGE WORKS, 1858–1875.

52. Change of Government. Action of the Metropolitan Board. Negotiations with the First Commissioner of Works. Change of Ministerial policy.
53. Act of 1858, giving greater powers to the Metropolitan Board.
54. Probable reasons which influenced the change. State of the river;—general approval of the principles of interception;—the Board's plans not necessarily final;—confident expectation that some process of deodorization would be used.
55. Construction of the Main Drainage Works.

ENLARGEMENTS FOUND NECESSARY, 1881–82.

56. New storm relief sewers. Enlargement of reservoirs.

THE THAMES EMBANKMENT, 1860–1874.

PAR.
57. Its necessity. Acts of Parliament. Construction.

ATTEMPTS TO UTILIZE THE SEWAGE, 1860 to 1873.

58. Discussions and considerations. Advertisements for competitive plans.
59. Hope and Napier's proposals. The Essex Reclamation Scheme.
60. Sewage from south side. Trials of the "Native Guano Company."

FORMER PUBLIC INQUIRIES AS TO ALLEGED EVILS RESULTING FROM THE SEWAGE DISCHARGE.

61. Mr. Rawlinson's Barking Inquiry, 1868.
62. The Thames Conservancy Mud-bank Inquiries, 1867–80.

PART II.

THE SYSTEM UNDER WHICH SEWAGE IS DISCHARGED INTO THE THAMES BY THE METROPOLITAN BOARD OF WORKS.

63. Introductory.

GENERAL PRINCIPLE.

64. System of interception.

NORTHERN INTERCEPTION.

65. High, middle, and low level main sewers. Northern outfall sewer.

SOUTHERN INTERCEPTION.

66. High and low level main sewers. Southern outfall sewer.
67. Table showing magnitudes and dimensions.

ARRANGEMENTS AT THE MAIN OUTFALLS.

68. Reservoirs at Barking Creek and Crossness; their dimensions and working.

CAPACITY OF THE MAIN SEWERS FOR DISCHARGE.

69. Double nature of the work to be done. Sewage proper and rainfall.
70. The "separate system" not applicable to London.
71. Combination of the sewage and rainfall in one system.
72. Quantities actually discharged, and discharging capacities.

STORM OVERFLOWS.

73. Necessity for, and general nature of these.

COST.

74. Amount expended and to be expended on the main drainage works.

REMARKS.

75. Credit due to the Metropolitan Board and to their engineer in regard to the main drainage works.
76. Benefits to the metropolis.
77. Weak points of the system. The storm outlets.
78. The discharges from these are frequent and considerable, and occasionally of very offensive character. Evidence of this.

PAR.
79. No evidence of positive evils arising from these discharges; but they may increase hereafter so as to be objectionable.
80. Discharge of the sewage in its crude state. Deodorization originally contemplated; this subject belongs to the third head of inquiry.

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER.

81. Quantity of sewage proper discharged.
82. General nature of the problems of distribution.
83. Tidal currents and oscillation.
84. Circumstances of discharge at the main outfalls.
85. Gradual displacement, and progress of the sewage down the river.
86. Mixing action. Mixing of sea water, fresh land water, and sewage.
87. Chlorine test. Results shown thereby.
88. Accumulation of the sewage. Its dilution by fresh and sea water.
89. Effect of the mixing action on the permanent progress of the sewage out of the river.
90. Disadvantage of the mixing action.
91. Answer of the Metropolitan Board to these objections to their system.

PART III.

WHETHER ANY EVILS RESULT FROM THE SYSTEM UNDER WHICH SEWAGE IS DISCHARGED INTO THE THAMES BY THE METROPOLITAN BOARD OF WORKS.

92. Classification under five heads.

(A.)

INJURY TO THE HEALTHINESS OF THE DISTRICTS IN THE NEIGHBOURHOOD OF THE RIVER.

93. Complaints made.
94. Evidence received.
95. No serious injury to health substantiated.
96. But there is evidence of affections of a slighter kind.
97. Conclusions from this.

(B.)

GENERAL NUISANCE AND INCONVENIENCE FROM THE POLLUTION OF THE RIVER.

98. Limitation to the consideration of the circumstances occurring near the main outfalls.
99. General facts of the case.
100. Evidence upon it.

*Popular Evidence.*

101. Complaints made before the appointment of this Commission.
102. Evidence offered on this inquiry on behalf of the complainants.
103. As to the foul state of the water.
104. As to the deposit of foul mud.
105. Additional evidence offered.
106. Evidence, in answer, offered by the respondents as to the foul state of the water.
107. As to the foul mud.
108. Inspections by the Commission.

*Scientific Evidence.*

109. General nature of such evidence.
110. Scientific witnesses.
111. Results of chemical examinations.

*Remarks.*

PAR.
112. Overwhelming amount of evidence as to the facts of the nuisance.
113. Answers of the respondents to this evidence. Opinions of the Commission thereon.
114. Magnitude of the causes in action.
115. Nuisances confined to the river or its immediate neighbourhood.

(C.)

INJURY TO FISH.

116. Testimony of witnesses.
117. Alleged causes of the injury. Opinion of the Commission.

(D.)

POLLUTION OF WELLS NEAR THE RIVER.

118. Alleged danger.
119. Evidence on the point.
120. Answer of the respondents. Opinion of the Commission.

(E.)

THE FORMATION OF SHOALS OR BANKS WHICH MIGHT PREJUDICE THE NAVIGATION OF THE RIVER.

PAR.
121. Fears on this subject.
122. Previous inquiries. The Barking proceedings.
123. The Mud-bank Arbitration.
124. Opinion of the Commission.

CONCLUSIONS.

125. Summary of the general conclusions at which the Commission have arrived in regard to the first two subjects of their inquiry.

# FIRST REPORT.

TO THE QUEEN'S MOST EXCELLENT MAJESTY.

MAY IT PLEASE YOUR MAJESTY,

1. WE, the Commissioners appointed by Your Majesty for the purpose of inquiring into the effects of the discharge of the Sewage of the Metropolis into the River Thames, humbly report to Your Majesty, as follows.

2. Your Majesty's instructions to us have directed our attention to three distinct subjects of inquiry, viz.:

(1.) "The system under which Sewage is discharged into the Thames by the Metropolitan Board of Works;"

(2.) "Whether any evil effects result therefrom;" and,

(3.) "In that case, what measures can be applied for remedying or preventing the same."

3. At an early period of our proceedings we determined that it would be expedient to limit the inquiry, in the first instance, to the first two of these subjects, as the consideration of the third must be dependent on the conclusion we should arrive at in regard to the second. And we believed that if we should find any such evil effects existing, it would be advisable to afford opportunity for the consideration and suggestion of remedies.

We have now formed the opinion, that the discharge of the sewage does produce certain evil effects of sufficient importance to justify us in entering upon the third head of inquiry; but before doing so we think it right, for the reason we have mentioned, humbly to present to Your Majesty a full Report of our proceedings hitherto.

4. After receiving from Your Majesty's Secretary of State for the Home Department various papers directing our attention to the complaints that had been made of the state of the river, we invited evidence on the matter, and the following parties appeared before us.

*As Complainants.*

The Corporation of London (as Port Sanitary Authority).
The Thames Conservancy Board.
A "General Committee for the protection of the lower Thames from pollution."
The Erith Local Board, and some other local authorities and bodies.

*As Respondents.*

The Metropolitan Board of Works.

At the outset of the proceedings the Metropolitan Board of Works applied for leave to attend the inquiry by counsel; and as it appeared to us that the matter had the character of a complaint, and a denial of the truth of that complaint, and that there would be a difference on the facts presented to us, involving examination and cross-examination which could best be conducted by the respective parties, we thought it right, in the interest of our inquiry, to admit the attendance of Counsel for those parties who thought fit to avail themselves of their assistance. Counsel have accordingly attended on behalf of each of the parties above named, except the Thames Conservancy Board.

We have now held in all fifty-nine meetings, at forty-six of which the parties were in attendance. During these 126 witnesses have given evidence, some at great length, their examination and cross-examination having been undertaken by able counsel. A large body of persons, of various classes in life, have testified to the facts, while the scientific aspects of the case have been presented to us by eminent engineers, chemists, medical men, and others. The case has been further illustrated, on both sides, by the production of a large number of plans, tables, and other documents, prepared in most elaborate detail.

5. As the subjects brought before the Commission have often been discussed at previous times, it may be useful to give a notice of the more important proceedings that have taken place in regard to the drainage of the Metropolis, and of the views that have from time to time been entertained thereon.

Our present Report may, therefore, be conveniently divided under three heads.

## PART I.

HISTORICAL NOTICE IN REGARD TO THE DRAINAGE OF LONDON.

## PART II.

THE SYSTEM UNDER WHICH SEWAGE IS DISCHARGED INTO THE THAMES BY THE METROPOLITAN BOARD OF WORKS.

## PART III.

WHETHER ANY EVIL EFFECTS RESULT THEREFROM.

# PART I.

## HISTORICAL NOTICE IN REGARD TO THE DRAINAGE OF LONDON.

### Early History down to 1830.

6. The most important feature of modern town drainage, namely, the removal of the house sewage by water in the drains, is of very late introduction.

As the area of the metropolis was gradually covered with buildings, sewers became necessary; but they were originally intended only to cover or supply the place of natural streams and ditches, and so to carry away the rainfall from the fields, roads, and roofs of the houses.

7. The subject of drainage in this sense had attracted the attention of the British Legislature at an early period. As far back as 9 Henry III., 6 & 8 Henry VI., 4 Henry VII., and 6 Henry VIII., statutes were made for the purpose of partially regulating the conditions under which works were to be executed. These acts, however, were of but a local nature; the first measure of a general character was the celebrated "Bill of Sewers," which was passed in the 23rd year of the reign of Henry VIII., 1531, cap. 5., and which appears to have laid the foundation of modern legislation in the class of works now under consideration.

Subsequently to this Act there were others by which the original Bill of Sewers was continued, amended, and explained. These measures were usually applicable to the country in general; but in the metropolis, owing to the rapid increase of buildings, the legislature was obliged to intervene more frequently, in order "to render more "effective the powers granted by previous Acts of Parliament for making, enlarging, "amending, and cleansing the vaults, drains, and sewers, within the City of London "and the liberties thereof."

A curious paper written by Sir Christopher Wren in 1678, and still preserved in M.S., proposed some important improvements in regard to "y$^{e}$ new sewers," "and "y$^{e}$ back waters in St. Margaretts, Westminster."*

The creation of new quarters of the town, themselves larger than the city, and the peculiar constitution of the local government bodies, led to a subdivision of the districts, and consequently of the management of their underground drainage; and in the eighteenth century the legislative Acts became more frequent.

In 1732, the River Fleet, which previously had been a navigable stream, was covered in, and by Act of Parliament formed into a sewer, below Holborn. The Ranelagh and the King's Scholars Pond sewers, and other important arterial drains, were also closed in about the same period.

At the beginning of the present century it was penal to discharge sewage or other offensive matter into the sewers, which were regarded as the legitimate channels for surface waters only. All offensive house refuse was collected into *cesspools*, the contents of which were removed from time to time, and carted away for use in the country as manure.

8. About 1810, an invention was introduced which had a very important effect on the drainage system, namely, the *watercloset*. Its adoption was at first slow, but its advantages in promoting domestic cleanliness became gradually appreciated by the public, and after 1830 its progress became rapid and remarkable.

The waterclosets were originally made to discharge into the cesspools; but the large addition caused to their contents in this way rendered it necessary to introduce overflow drains from them running into the street sewers. But as buildings increased, and cesspools became more numerous, they were found, particularly when badly constructed or neglected, to be sources of annoyance, discomfort, and disease; and as the invention of the watercloset offered facilities before unknown for the entire removal of the

* See a paper by Sir Joseph Bazalgette on the Main Drainage of London, Min. Proc. Inst. C. E., Vol. xxiv., 1864-65.

sewage, it became the practice to discharge it, with the aid of a sufficient water supply, into the street sewers, from which it was conducted into the River Thames.

The effect of this change was to pollute the sewers, and to render it necessary to cover such of them as had before been left open; but on the other hand there was this advantage, that the natural flow of the streams became largely aided by the artificial water supply passing from the houses, which tended to keep the sewers clean.

## Early Schemes.—1830–1846.

9. It was soon perceived that the purity of the Thames would be materially affected by this change; and the matter attracted considerable attention, owing to the fact that the water supply of the metropolis was largely drawn from the river within the tideway;—a state of things that was not wholly abolished till about the year 1855.

As early as 1834 the idea arose that, while still retaining the advantages of sewer drainage, it would be possible to carry off the refuse by *the principle of interception*, without polluting the river in the neighbourhood of London. The originator of this idea was the celebrated painter John Martin. In June of that year he designed a plan, according to which it was proposed to embank both sides of the river Thames, and to construct an intercepting sewer in each embankment, for the purpose of collecting the sewage, and conveying it to points in the river below the most populous part of London. The plan excited considerable attention; its details appear to have been studied with some care, and a committee of gentlemen was appointed to examine it;* but it was in advance of the time, and as serious objections were urged against it, it was not proceeded with. At the same time, as it formed such a striking anticipation of the plan ultimately adopted, it deserves a mention in history.

10. Other proposals followed, particularly one in 1845 by Mr. Thomas Wicksteed (then engineer of the East London Waterworks Company) who renewed Martin's interception proposal, carrying the points of outfall down to Barking Creek on the north and to Greenwich Marshes on the south side, adding provisions for deodorizing the sewage by chemical means, before its discharge.†

In 1846 a company was established under an Act of Parliament for collecting sewage directly from some of the principal London sewers, and utilizing it upon land in the country; but the attempt proved a failure, and was soon abandoned.

## Commissions of Sewers to 1847.

11. The drainage of the metropolis was at this time under the charge of separate local "Commissions of Sewers." In 1847 there were no less than eight of these bodies, each exercising an independent sway over its own district.

These were—

The City of London.
Westminster and part of Middlesex.
Holborn and Finsbury.
The Tower Hamlets.
St. Katherine.
Poplar and Blackwall.
Greenwich.
Surrey and Kent.

Each consisted of a Board with almost unlimited powers over its own district; with its own peculiar mode of conducting business; with a special staff of engineers or surveyors, clerks, superintendents, &c., &c.; and each with its own peculiar regulations as to the sizes of drains, their rates of inclination, mode of execution, and cost.

12. Under such a divided management it was hardly possible that any advantageous general principles of drainage could be acted on. No uniform system was observed either as to the dimensions of the main sewers, or their rate of fall; nor was any attempt made to conform the works of the several districts to any one general plan.

The sizes, shapes, and levels of the sewers at the boundaries of the different districts were often very variable. Larger sewers were made to discharge into smaller ones; sewers with upright sides were connected with egg-shaped sewers; and egg-shaped

* Among this Committee were the Earl of Euston, Colonel Sir Frederick Trench, M.P., and General Sir Patrick Ross. Their report was published 23rd April 1836.

† Report published by Weale, 27th August 1851.

sewers with the narrow part uppermost were connected with similar sewers having the narrow part downwards. Indeed, so little care and design were observed in these matters, that even the governing bodies themselves appeared not to be in possession of any accurate information as to the dimensions or arrangement of the works actually existing under their control.

The evils of this system, as manifested in the defective drainage of the metropolis, were beginning to be seriously felt, and some of the Boards decided to take more active steps to improve matters. As an instance of this, it may be mentioned that the most important body out of the city, the Westminster Board of Sewers, adopted in 1844 the unwonted course of appointing an engineer (or surveyor, as he was then called) by a stringent competitive examination. Other bodies also exerted their powers, but the system generally was too defective to admit of much real improvement, and it was only by a radical change that this could be effected.

### The Consolidated Commission of Sewers, 1848 to 1855.

13. This change was brought about by the action of public opinion in 1848. The subject came forward in the parliamentary session of that year, and the result was the passing of an Act on the 4th September 1848 (11 & 12 Vict. cap. 112) "to consolidate the Metropolitan Commissions of Sewers."

14. This Act empowered Her Majesty to issue a Commission uniting the whole of the before mentioned authorities, with the important exception of that in the City, into one general Board under the above title, whose jurisdiction should extend to any "places or parts in the counties of Middlesex, Surrey, Essex, and Kent, or any of "them, not more than twelve miles distant in a straight line from St. Paul's Cathedral, "but not being within the city of London or the liberties thereof."

The Commission had power, not only to keep the sewers in order, but also to make new ones "necessary for effectually draining the area within the limits of the Commission:" but the powers did not point to any drainage measure, on a large scale, for removing the sewage from the neighbourhood of London.

It was, however, enacted that every house should be provided with a proper water-closet or privy, and should be drained into the main sewers; and the Commissioners were required to carry out these drainage provisions.

As a consequence of the general want of information, it was also enacted that they should cause to be made a complete survey and map of the metropolis within the limits of their jurisdiction, on which should be shown the levels, the particulars of all sewerage works, and such other indications as might be necessary for the purposes of the Act, or for the general advantage of the ratepayers. This was afterwards carried out with the co-operation of the Ordnance Office, resulting in the well known large-scale survey which has been of such great public use.

The area controlled by the Commissioners was divided into separate "Sewerage Districts," on each of which a rate could be levied for the expenditure incurred by the Commission.

15. The Royal Warrant issued under the authority of this Act appointed twelve Commissioners, to whom were added five ex-officio representatives from the City. They were unpaid, and the duration of their office was fixed at two years.

16. They began zealously on the improvement of the house drainage, the abolition of cesspools, and the introduction of pipe-sewer communications between the houses and the main drains; but they did not remain long in office, for in 1849 they were superseded by a second body, who took steps towards adopting measures of a more comprehensive character. The new Commission held that the sewage should be kept out of the Thames altogether, and instructed their consulting engineer, Mr. Austin, to prepare a plan for laying down lines of sewers converging into large tanks or "sumps," from which the sewage could be pumped up and conveyed away for agricultural purposes. A rival plan was however offered by the chief surveyor, Mr. Phillips, who strongly opposed this diversion of the sewage, and recommended an extension of the intercepting system for discharging it into the Thames below London.* Both these plans found strenuous supporters, and the Commissioners, being unable to agree to either, took the step of advertising for competitive plans for a complete systematic drainage of London.

* *See* printed Minutes of the Commissioners.

One hundred and sixteen designs were sent in, but the Commissioners were still unable to come to any decision upon them, and in the midst of the perplexity, and of the public excitement thereby produced, the Commission resigned.

17. The third Commission comprehended several gentlemen of eminent engineering ability, among whom were Sir John Burgoyne, Mr. Robert Stephenson, Mr. Rendel, Mr. (afterwards Sir) Samuel Morton Peto, Colonel Dawson, R.E., and Captain Vetch, R.E. This Commission began by classifying and arranging the competitive plans sent in to their predecessors. Some of these had much merit, particularly one by Messrs. Maclean and Stileman, which, adopting the interception principle, carried the outfalls to the sea, and made use of the sewage for reclaiming waste lands on the Essex coast. The Commissioners, however, eventually reported, on 8th March 1850,* that none of the plans could be recommended for execution, and they determined to appoint an engineer of their own selection to prepare a scheme for the main drainage of the metropolis, taking advantage of all the pre-accumulated information on the subject. The engineer selected was Mr. Frank Forster, who had long been one of the most able railway assistants of Mr. Robert Stephenson.

18. Mr. Forster, with the aid of two other officers of the Commission, Messrs. Grant and Cresy, first prepared designs for the drainage of the south side, and presented his Report thereon 1st August 1850.† Adopting the fundamental principle shadowed forth in former plans, he proposed to form one main intercepting sewer; but, owing to the physical configuration of this part of London, none of the water would flow away by gravitation. There was to be a pumping station on the banks of the Ravensbourne, to raise the water about 25 feet, and a second pumping station to raise the water from the continued sewer into a reservoir, in Woolwich marshes, which was to receive it during the intervals of the tides. The sewage was to be discharged into the river at the top of Woolwich Reach, eight miles below London Bridge.

Mr. Forster's Report on the northern drainage, in the preparation of which he was assisted by Mr. Haywood, the engineer of the City Commission of Sewers, bears date 30th January 1851. He proposed to intercept the whole of the existing drainage by means of two main conduits, the first at such a height as to allow of the discharge of the water by gravitation, and the second at a lower level to meet the outfalls of the lowest sewers. These intercepting lines were to converge to a point on the eastern bank of the River Lea, where a pumping station was to be erected, and the waters from the low level sewer were to be raised to the upper one. From thence the united sewers were to lead to a reservoir near Galleon's Reach, and the sewage was there to be discharged at such period of the tide as to prevent its reflux to London.

The positions of the main sewer outfalls proposed by Mr. Forster are shown by the letters F. on the plan, Appendix C.D.

Mr. Forster calculated his works to carry off a fall of rain equal to $\frac{1}{4}$ inch in 24 hours, in addition to the daily flow of sewage.

The total lengths of intercepting sewers to be made were, on the north side about 38 miles, and on the south side about 13 miles. The estimated cost was 1,500,000*l.*, excluding land and compensations.

19. The Commission had no power to raise the money to carry out these works, and was in its turn superseded; and a fourth Commission, appointed in 1852, renewed the consideration of the plans proposed by Mr. Forster; but Captain Vetch, R.E., a member of that Commission, propounded a different scheme of his own, which again raised a division among the Commissioners as to the relative merits of the plans before them. Mr. Frank Forster's health gave way under the anxieties of his position; he resigned his office, and shortly afterwards died.

20. The fourth Commission was superseded by a fifth, appointed late in 1852, who were met at the outset of their proceedings by a plan submitted to Parliament by a private company, under the title of the "Great London Drainage." The discussion of this scheme extended over a great part of the Session of 1853, and it was ultimately rejected by a committee of the House of Commons.

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* The Report is inserted in the Min. Proc. Inst. C.E., Vol. xxiv., p. 513.
† Min. Proc. Inst. C.E., Vol. xxiv., p. 518.

Immediately after this, Mr. (now Sir Joseph) Bazalgette, who had been appointed engineer to the Commission, was instructed, in conjunction with Mr. Haywood, to prepare a scheme for the drainage of London, north of the Thames; these gentlemen took as a basis the proposals of Mr. Frank Forster, modifying and improving them, so as to meet the altered circumstances of the metropolis, and their plans were submitted to and approved by Mr. Robert Stephenson and Sir William Cubitt (the consulting engineers to the Commission) in the early part of 1854. The outlet selected by them, marked B.H. on the map, Appendix C.D., was in the same place as that proposed by Mr. Frank Forster for the north side.

21. Shortly before this time the subject of the metropolitan sewage had been taken up by a public body, who interested themselves in matters of a sanitary nature,—the General Board of Health. In several of their reports they had pointed out what they considered to be serious defects in the existing state of things, and in 1854 a plan was brought forward, under their auspices, for entirely remodelling the whole London drainage by introducing what was called the "separate system," *i.e.*, the system of separating the sewage from the rainfall, and providing independent channels for the removal of each.

This plan received the countenance of the then Secretary of State for the Home Department, who communicated his opinion to the Sewers Commissioners. This body, feeling that they could not agree with the Government on the point, informed the Home Secretary of their decision, and forthwith resigned.

A sixth Commission was appointed at the end of 1854, partly by the Government, and partly by election. They invited new plans, and considered several of them, but did not arrive at any solution of the question.

22. In the meantime the state of the River Thames within the Metropolis was becoming very alarming. As already stated, the first consolidated Commission, immediately after its appointment in 1848, had begun to take cognizance of the large extent to which cesspools existed in the middle of the populous districts. We have it in evidence that at that time these collections of pestiferous matter were some 200,000 in number, containing an aggregate capacity of about $5\frac{1}{4}$ millions of cubic feet. The Commissioners resolved to put their powers in force by doing away with them. Their abolition was gradually accomplished, the contents being pumped out and discharged into the Thames; watercloseets were compulsorily substituted, and house drains from them were connected to the main sewers, which then discharged into the Thames in the heart of London.

The effect of this wholesale change soon became manifest in the foul state of the river, the noxious smell of which was intensified by great deposits of sewage matter on the large flat banks, left dry at low water, close under some of the finest and most populous parts of the metropolis; and it was clear that this evil must continue to increase with the growth of the population.

But this was not all. The metropolis had suffered severely from the cholera visitations in 1831–2, 1848–9, and 1853–4, and strong suspicion prevailed that defective drainage had contributed to the alarming mortality.

23. It was perceived that, although the Consolidated Commission of Sewers was an improvement on the original divided jurisdiction, it was still inefficient to carry out the great work of purifying the river. This body had been charged with control over a large area, and with large powers of rating, but they had hitherto attempted only one large work, namely, a sewer in Victoria Street, which, after costing a large sum, had fallen into ruins. There were many anomalies and difficulties in regard to their jurisdiction, and they themselves recommended large changes. Under these circumstances the Government decided to create a new representative body; and a Bill to effect this object was accordingly brought in by Sir Benjamin Hall, the First Commissioner of Her Majesty's Works and Public Buildings, on 16th March, 1855. It was carefully discussed in both Houses, and it received the Royal Assent on the 16th August in that year.

### The Plans of the Metropolitan Board of Works, 1856.

24. The Act above mentioned, 18 & 19 Vict. cap. 120, was entitled "An Act for the better Local Management of the Metropolis."

The object was twofold; first, to create a number of local or District Boards of Works, each of which should generally control the public structural matters in its particular district, and should have entire charge of the local drainage, comprising all sewers except the more important ones, which were termed *main sewers*.

Secondly, to form a Corporate Board, to be called the *Metropolitan Board of Works*, elected by the ratepayers. The duties of this body were of a more general character. They had power to control the district boards, to regulate streets and buildings, and generally to superintend all great municipal works of construction. But their most important office was to take charge of the main sewers of the metropolis, and in particular to construct works for a comprehensive system of main drainage.

The chief portions of the Act referring to this latter provision were as follows:—

CXXXV. The sewers mentioned in Schedule D. to this Act, being the main sewers . . . . . , shall be vested in the Metropolitan Board of Works;

And such Board shall make such sewers and works as they may think necessary for preventing all or any part of the sewage within the metropolis from flowing or passing into the river Thames in or near the metropolis;

And shall cause such sewers and works to be completed on or before the 31st day of December 1860.

And the said Board shall cause the sewers vested in them to be constructed, covered, and kept, so as not to be a nuisance or injurious to health; . . .

And may cause the sewage and refuse from such sewers to be sold or disposed of as they may see fit, but so as not to create a nuisance. . . . .

CXXXVI. Before the Metropolitan Board of Works commence any sewers and works for preventing the sewage from passing into the Thames, as aforesaid, the plan of the intended sewers and works for the purpose aforesaid, together with an estimate of the cost of carrying the same into execution, shall be submitted by such Board to the Commissioners of Her Majesty's Works and Public Buildings; and no such plan shall be carried into effect until the same has been approved by such Commissioners.

Powers were given to both the Metropolitan and the District Boards to levy rates in order to provide for their expenditure, and to borrow money when necessary.

The Metropolitan Board were bound to send to Government an annual report of their proceedings, and a statement of their accounts, which were to be laid before Parliament.

25. The Metropolis Local Management Act came into operation in January 1856, and the Board, having appointed their officers, immediately proceeded to the consideration of the whole question of the main drainage of the metropolis, and instructed their chief engineer, Mr. Bazalgette, to report, at the earliest possible period, as to the works necessary for the accomplishment of the object. In accordance with these instructions, a plan was prepared, the main features of which were similar to that of 1854, but modified and improved.

26. In accordance with the proviso in the Act, the plan prepared by Mr. Bazalgette was submitted to Sir Benjamin Hall on the 3rd of June 1856.

At this point of the history the question arose as to the most appropriate *position of the outfalls* for the main sewers. In the plan presented by the Board the outfalls were shown at Barking Creek on the north side, and in the Plumstead marshes on the south side. The particular points are marked A. on the plan, Appendix C.D.

As Sir B. Hall had been previously given to understand that the position of the outlets was to be fixed by the Board in accordance with certain data obtained by them in 1851, he thought it desirable that some person should be appointed to test the accuracy of such data. Accordingly he communicated with the Admiralty, and requested them to name some person for the purpose, who was thoroughly conversant with the Thames. The Admiralty named Capt. Burstal, R.N. (who was shortly afterwards appointed Secretary of the Thames Conservancy Board), and he was directed to inquire into the matter.

Captain Burstal accordingly made a number of float experiments, to ascertain the extent of the tidal action in the Thames, and reported thereon to the First Commissioner in a letter dated 30th June 1856, a copy of which has been put in evidence by Captain Burstal before this Commission. (*Q.* 6491.)

Immediately on the receipt of this report, the First Commissioner wrote to the Metropolitan Board of Works a letter, dated 2nd July, concluding as follows: —

"By the Metropolis Act of 1855 it is provided that the Metropolitan Board of Works shall make sewers and works for preventing all or any part of the sewage within the metropolis from flowing or passing into the Thames in or near the metropolis. But the scheme submitted for the approval of the First Commissioner actually provides that the sewage shall flow into the Thames at a point within the metropolis. It consequently follows that, before any such scheme can be carried out, it will be necessary to call upon Parliament to

repeal so much of the Act of last session as provides for the purification of the River Thames within the metropolis. The First Commissioner feels he cannot undertake to do this, and, considering that the scheme is entirely at variance with the intentions of the Legislature as set forth in the Act which passed last August, he considers it to be his duty to return the plans which were submitted for his approval.

27. On the 5th of November 1856, a second plan was submitted, having outfalls two or three miles lower, namely, at the points marked B. on the map, Appendix C.D.

The Metropolitan Board gave to the First Commissioner an intimation that they had considered other plans for discharging the sewage into the river below Gravesend: but that, as such an extension would add between one and two millions sterling to the outlay, and as the increased expenditure would be incurred, not to benefit the inhabitants of the metropolis, but to meet the wishes of persons residing on the banks of the river, the Board had declined to entertain these schemes. Notwithstanding, if Her Majesty's Government deemed such a scheme desirable, the Board would readily undertake the work, the Government providing for such additional outlay out of the national revenue.

Sir Benjamin Hall on examining the plan, considered that, although the proposed points of outfall were just outside the metropolitan boundary, the sewage would flow back into the metropolitan area, and he returned that plan also. The two plans which the Board had submitted were, in fact, considered by him wholly at variance with the spirit and intent of the Act, and with the plain intention of the Legislature.

In the meantime, the First Commissioner, having reference to Captain Burstal's previous investigations on the motion of the tides, had desired him to specify the nearest points at which the sewage of the metropolis could be discharged without reflowing into the metropolitan area. In reply to this, Captain Burstal wrote the letter, dated 18th November 1856, which is printed in Appendix L.

He said,—

> I should therefore submit that the nearest point to London at which the [southern] outfall be made be in the upper part of Erith Reach, 15 miles from London Bridge, $\frac{1}{8}$ mile from Erith Church, and $\frac{1}{4}$ mile below Jenningtree Point, nearly opposite Rainham Creek.
>
> * * * * * * *
>
> For similar reasons, I would suggest that the outfall on the north side be at Rainham Creek.

These points were about $1\frac{1}{2}$ mile lower than those named in the last proposition of the Board, and they were afterwards known by the designation B*. They are shown with this mark on the plan, Appendix C.D.

28. The Metropolitan Board for the time adopted the recommendation, and sent to Sir B. Hall on the 22nd December a third plan, thus amended. The First Commissioner, however, determined to submit the whole subject of the metropolitan drainage to the consideration of independent professional advisers, and appointed as Referees for this purpose Captain Douglas Galton, R.E.; Mr. James Simpson, the Engineer of two of the London Water Companies; and Mr. Thomas E. Blackwell, Engineer of the Kennet and Avon Canal Navigation.

The reference to these gentlemen was made on the 31st December 1856, and as their inquiry bears materially on the questions before us, it will be useful to notice it in some detail.

### The Inquiry of the Government Referees, 1857.

29. The instructions of the First Commissioner requested the Referees to consider the plans submitted by the Metropolitan Board; but expressed his wish that they should not confine their attention merely thereto, but should give him the fullest information they could afford him, reporting generally their views on the question of the main drainage of the metropolis and the points of outfall. The following extract will show the manner in which the question presented itself to the Government at that time:—

> The plans now sent to you fix the outfalls at the points already indicated [in and near Erith Reach], but, inasmuch as it is desired, by the inhabitants of towns bordering upon the river below the 15 mile point, that the main sewer should be extended, and that the outfall should be placed at a greater distance from the metropolis, provided funds are obtained for the purpose of meeting the increased expenditure, the First Commissioner wishes you to report upon any such more distant points of discharge as may fairly meet the requirements alluded to.

The First Commissioner also directed the Referees to consider the subject of the most effectual means of utilising the sewage, "as a strong feeling seemed to be "entertained by members of the Metropolitan Board of Works, and others, that "the sewage of the metropolis might be made a source of profit."

He further directed them to obtain accurate information as to the amount of sewage discharged, as there had been great discrepancies in the statements made on this point at different times.

30. The Referees, having collected information from a great variety of sources, and having examined a large number of plans forwarded to them, reported to the First Commissioner on the 31st July 1857. The Report, which was very full and elaborate, was afterwards published, with a large mass of appended documents and plans, as a Parliamentary paper (3rd August 1857).

The Report was divided under four heads; viz.:—

1st. The principal features of the existing system of drainage in the metropolis; the system of drainage proposed by the Metropolitan Board of Works; and the amount of sewage for which provision should be made.

2nd. General consideration of the several schemes submitted for draining the metropolis.

3rd. The system of drainage which the Referees recommended, and the modifications in the plan of the Metropolitan Board of Works which this system would necessitate.

4th. The extent to which districts adjacent to London, which would be benefited by the proposed mode of disposing of the sewage, ought to contribute thereto.

The Report contained a large quantity of matter which, though important at the time, has, from the progress of events, now lost its interest; and attention may be confined here to such points as bear on the present inquiry.

31. The amount of sewage and rainfall for which the plan of the Metropolitan Board of Works provided was founded on a prospective population of 3,413,400 persons, with a discharge of sewage of 5 cubic feet per diem, to which was added a rainfall of $\frac{1}{4}$ of an inch per diem in the urban and $\frac{1}{8}$ of an inch in the suburban districts. This gave the following quantities* :—

| | Gallons per Diem. |
|---|---|
| Total sewage per diem | 106,623,000 |
| Rainfall, north side | 215,325,000 |
| Do. south side | 109,269,000 |
| Total maximum sewage and rainfall which the sewers were to be capable of removing | 431,217,000 |
| Or, in cubic feet per diem, about | 69,000,000 |

The Referees disagreed with this estimate, as their sewer gaugings gave higher results than those assumed by the Metropolitan Board of Works; and, after a somewhat elaborate statement of reasons, they recommended that 7 cubic feet of sewage should be estimated daily for each individual of an assumed population of about 3,578,000, and that provision should be made for an addition of rainfall (estimated at two-fifths of an inch during the eight hours of maximum flow), giving a total quantity of about 185,600,000 cubic feet per diem. To this they made a further addition for suburban areas, giving on the whole, in round numbers, 211,000,000 cubic feet per diem to be disposed of, or three times the quantity contemplated in the Board of Works plan. The Referees said, in reference to this plan—

We must express our decided opinion that this plan does not provide for the removal of a sufficient quantity of sewage from the population of the metropolitan districts, including the prospective increase, and that the provision for the removal of storm water during rain is not carried to the extent necessary to prevent the frequent pollution of the river.

32. With respect to the *position of the outfalls*, proposed by the Metropolitan Board, the remarks of the Referees may be inserted entire.

The outfall for the sewage of the north side is situated at the confluence of the Rainham Creek with the River Thames at a point which is designated as B* on the maps of the Metropolitan Board of Works; the outfall for the sewage of the southern side being placed at a spot opposite, on the south side of the river.

We have received from a committee of gentlemen who reside in the neighbourhood of Erith and Gravesend a statement of their objections to this outfall.

With respect to this locality we have to observe that, if a stream loaded with sediment be poured into a river, the sediment will have a tendency to deposit and to form shoals, unless the place at which the stream is turned into the river be subject to the action of a strong current. Erith Reach, at the head of which the outfall has been placed, is stated by Mr. Stephen W. Leach, the engineer of the Conservancy of the Thames, to be at the present time peculiarly liable to shoal; and we, therefore, consider that upon this ground alone it would be very injudicious to select this as the point of outfall.

* *See* Table in Referees' Report, page 13.

We have also carefully studied the very valuable series of float experiments made by the late Mr. Frank Forster, engineer to the Metropolitan Commissioners of Sewers, and those made by Captain Burstal, R.N., in the course of last autumn, as well as some float experiments made recently by Mr. Homfray, the engineer of the Erith and Gravesend Committee; and we have also made some experiments ourselves at this place. The conclusion at which we have arrived upon the subject is as follows; viz.:—

That a float put into the centre of the stream at high water will move down the river with the ebbing tide, and ascend again with the flowing tide, and that at the end of a fortnight it will be found to have reached a point in the river about five miles below that at which it was put in. But the part of the river selected for the outfall B* is full of shoals which cause eddies and slack water in these places, as is shown by the frequent tendency of the floats to set inshore; and consequently the sewage would be liable to form deposits of mud upon the banks, of the same putrescible character as is found in the Thames in London at the present time.

It must also be recollected that, whilst the floats, when once put in, were followed up and down the river in the strength of the stream, the sewage would be turned in continually twice every day; and that much of that portion of it which would flow into the river during the ebb tide would hang about in slack water, and be liable to be carried up with the flood to a point much above that which is assigned as the probable limit by float experiments made in the fairway of the channel. It is worthy of remark that the water is sometimes salt in the river as high as Barking Creek and Woolwich.

Also, it cannot be denied that sewage turned into the river in two concentrated streams above Erith would be much more objectionable to the inhabitants of that locality than the same sewage flowing into the river by a number of separate channels at points several miles higher up.

With the view of avoiding the objections, that have been urged by the inhabitants of Erith against the outfall at B*, Mr. Bazalgette has proposed to bring the southern sewage across the river, and to convey the united stream to Mucking Flats. Although we concur with Mr. Bazalgette in thinking it expedient to seek for an outfall in that locality, we are of opinion that the particular point which he has selected is objectionable, because it is situated in a part of the river subject to slack water during a great portion of the ebbing tide.

The Referees summed this up in their conclusions, as follows:—

That the proposed outfall at B* in Erith Reach is objectionable because it would not effectually prevent the sewage from returning within the limits of the metropolitan boundary; because it would have a deleterious effect on the health of the district; and because it would probably be prejudicial to the navigation.

33. In Section III. of their Report the Referees explained a plan which they, considering all the circumstances, had prepared and recommended for adoption.

They considered that the system of interception as first laid down by Mr. Frank Forster, and subsequently followed up by Mr. Bazalgette, must form the basis of any sufficient scheme; and they therefore adhered to the general plan of intercepting from a higher level, and of pumping from such levels as were too low for a gravitating discharge. But they differed somewhat from these authorities as to the detailed mode in which these principles should be carried out.

34. In regard, however, to the discharge of the sewage, they proposed a most important modification, namely, to remove the outfalls to a point much lower down the river.

On this point their remarks were as follows:—

After a careful consideration of this question in all its bearings, we are of opinion that the best mode of disposing of the sewage of the metropolis is to place it where it will be rapidly and certainly mixed with large volumes of water, and be finally carried into the sea. We consider that the most effectual method of securing this object is to place the outfall at some point in a deep tidal river where the range of the tide is considerable, where the set of the stream is strongest against the shore, and where its outward flow is assisted by the fresh water from a large drainage area.

There are two points on the River Thames which entirely fulfil these necessary conditions, viz., one on the north side very near to the Mucking Lighthouse, in Sea Reach; and the other on the south side, at Higham Creek, in the Lower Hope. At both of these places the water near the shore is very deep, and the ebb-tide very strong.

We consequently made some tidal experiments at these places with the assistance of Captain Burstal, R.N.; and we also received, from the committee of gentlemen from Erith and Gravesend, the results of a valuable series of tidal experiments made by Messrs. Homfray, their engineers, at the same place.

And we also consulted Captain Bullock, R.N., upon the subject, who, by his valuable surveys, is thoroughly acquainted with the River Thames.

The results of these experiments are, briefly, as follows:—At both places the currents are very strong in the ebb-tide, and a considerable period of slack water occurs during the flood; and, unlike the upper parts of the river, where the tide is concentrated into one stream, the great expansion in the breadth of the river at Sea Reach causes great variations in the set of the currents at different parts; thus, while the ebb-tide sets upon the northern shore of Sea Reach, the flood-tide sets upon the southern shore. This was shown by the fact that floats which entered Sea Reach with the ebb-tide set in towards the northern shore, and were not carried up the river again with the following flood-tide, whilst a large volume of fresh sea water from the Nore comes up along the south shore at every tide. The strength of the current at both the above-mentioned places is sufficiently great to prevent any deposit of materials brought down by the sewers from taking place in the bed of the stream; and the great expanse of water, the continual accession of clean water, and the rapidity of current, would ensure the mixing of the sewage with water under the most favourable circumstances, and at a point in the river where the shores are almost uninhabited.

These are the only places in the river, either above or below, which appear to us entirely to fulfil the conditions essential to the object in view; and we have, therefore, selected them as the points of outfall for the metropolitan sewage.

The points of outfall proposed by the Referees are shown in the sketch map, Appendix C.F.

35. The Referees proposed that the sewage should be carried to these points of outfall by a main channel on each side of the river, delivering at low water.

That on the north side would, reckoning from the boundary of the Metropolitan area, be about 20 miles long; and that on the south side about $16\frac{1}{2}$ miles long.

The north channel was to be 39 feet broad and $16\frac{1}{2}$ feet deep; the south channel 37 feet broad and 16 feet deep. The fall was to be six inches per mile, which it was calculated would give a velocity of $2\frac{1}{2}$ feet per second, sufficient to keep them clear of deposit.

But, in order to ensure this velocity at all times, it was proposed, during dry weather, to admit tidal water from the Thames to the head of the channels by means of reservoirs formed to equalise the flow.

36. The Referees considered that the great extent to which the sewage would be diluted, after the outfall channels were fed with the tidal water at their heads, would render them comparatively innoxious streams. It was not, therefore, in the first instance, proposed to cover them, except where they passed populous neighbourhoods, or where they were formed by tunnelling under raised ground.

The Referees were of opinion that it would be necessary to provide storm overflows for certain sewers near the point of interception to convey the water directly into the river, and to discharge at all times of tide.

37. They estimated the cost of the works they recommended as follows:—

| | £ |
|---|---|
| Intercepting and collecting main sewers, and their connexion with the main outfall channels - - - | 3,080,465 |
| Main tidal outfall channels - - - - | 2,356,800 |
| | £5,437,265 |

exclusive of charges for superintendence, &c., assumed at 4 per cent.

38. The Referees devoted much attention to the subject of the possible utilization or deodorization of the sewage, and it may suffice here to give their general conclusion on the facts then before them:—

That, under these circumstances, and having regard to the inexpediency of making the question of the effectual drainage of the metropolis dependent on commercial considerations, the only practicable mode of disposing of the sewage of the metropolis is to provide for its rapid removal from inhabited districts, and for its collection in main outfall channels, where private enterprise, under proper control, may be at liberty to utilize it; but that, when not required for purposes of utilization, these channels should provide for its flow in the most expeditious manner into the sea.

39. The Referees concluded as follows:—

In conclusion, we would impress upon you our decided conviction that, if the Thames is to be completely purified, no plan less comprehensive than the one which we have suggested will effect this object.

The estimated expense of this plan is considerable; and some improvement upon the existing state of things might possibly be obtained for a smaller outlay; but a diminution in the dimensions of the sewers does not proportionately diminish the cost of their construction; and, moreover, the increase of population, which is so rapidly taking place in every direction round the metropolis, would necessitate the extension of any less comprehensive plan than the one which we have suggested, at no very distant period.

40. The Appendix to the Referees' Report contained a great mass of information, among which may be specified:—

Elaborate chemical investigations by Messrs. Hofmann and De Witt, and Mr. Etheridge.

Tables of population, rainfall, percolation, &c.

Experiments on the effect of running water in moving solid substances.

Data by Captain Bullock, R.N., Captain Burstal, R.N., Mr. Leach, Mr. Frank Forster, and Mr. Homfray, as to the River Thames, and the tidal movements therein.

Protests and evidence against the proposed measures of the Metropolitan Board of Works, by parties interested in the lower part of the river.

## Discussions of the Subject, 1857–8.

41. The report of the Referees was submitted to the Metropolitan Board, who, in October 1857, wrote to Her Majesty's Office of Works a letter objecting to the proposed scheme on several grounds, the most important of which were the proposed locality and mode of discharge into the Thames, and the long outfall sewers leading thereto. They urged that the proposed open sewers would be a greater nuisance than the river, by reason of the less dilution of the sewage; and that the plan of discharging only at low water would neutralize a considerable part of the advantage proposed to be gained by going 15 miles lower down.

The Board also objected to the proposed enlargement of the area to be drained, and to the increase in the dilution of the sewage, as requiring larger dimensions of the sewers.

On the 5th November 1857 a conference was held between the various parties at the Office of the First Commissioner, and the questions at issue were fully discussed. The Chairman of the Metropolitan Board inquired whether Her Majesty's Government would be prepared to contribute the additional cost of executing the work if the Board should decide upon carrying the outfalls to Sea Reach. The First Commissioner stated that, in his opinion, Parliament would refuse to make any contribution to the works in question.

The Referees then wrote a letter to Sir Benjamin Hall, dated 12th November 1857. In regard to the points of discharge and the long outfall sewers they gave lengthy explanations. They said that the question of their being open or closed did not affect their efficiency, and they pointed out that they might be covered if thought desirable. They also defended the proposed mode of discharge, and added:

> But we have not selected the points of outfall named in our Report solely on account of their distance from the metropolis.
>
> Our objections to the outfall at B* in Erith Reach were mainly founded upon the fact that this reach is very liable to shoal, and that therefore the sewage when discharged there would hang about in the eddies and slack water, and, besides having a tendency to move up the stream with the next tide, would subside on the shores and form deposits of mud. These deposits would not only interfere with the navigation, but would, from their putrescible character, be very injurious to the adjacent inhabited districts.
>
> We selected Higham Creek and Mucking Lighthouse as the points of outfall, because, after a careful examination of the whole river, we considered, and do still consider, that these places fulfil the conditions essential to the discharge of the metropolitan sewage without injury to the river.

With regard to the proposed greater dilution of the sewage, the Referees reiterated their arguments, and added:

> We can only repeat that, if it be desired to preserve the River Thames from pollution within the metropolitan districts, that object will not be effected to a reasonable extent if the provision for rainfall be reduced below what we have recommended; and we are firmly convinced, from the considerations into which we have already fully entered, that the sewers proposed by the Metropolitan Board of Works would too frequently overflow into the river in London, and more frequently at the storm overflows into the rivers Lea, Roding, and Ravensbourne.
>
> The plan of the Metropolitan Board of Works would, as we have explained, permit a very frequent flow of sewage into the Thames during rain, at a time when the sewage would be highly charged with deleterious matter.

About this time resolutions were forwarded to the Metropolitan Board of Works from the principal Vestries and District Boards of the metropolis, urging them to withhold their assent from any scheme which should impose upon the ratepayers of the metropolis the burthen of carrying the sewage beyond those points which would satisfy the strict requirements of the statute; and on the 16th November the Board passed a resolution to the effect that to extend the points of outfall to Sea Reach at the cost of the metropolitan ratepayers would be unjust to them, and a contravention of the principle of the Metropolis Local Management Act.

42. On the 23rd November 1857 the Metropolitan Board resolved:

> That the reports of the Board on the main intercepting drainage of the metropolis, submitted to the Commissioners of Her Majesty's Works and Public Buildings, also the reports of Messrs. Galton, Simpson, and Blackwell, upon the same subject, be referred to the engineer of the Board, together with two other civil engineers, with instructions that they report to this Board as to the best means of carrying out the main drainage of the metropolis; and, in reporting on the expenses of the works which may be proposed, they will state, first, the amount necessary for carrying the sewage of the metropolis to B*, and, secondly, in case funds should be provided, the further cost of carrying the sewage to points of outfall in Sea Reach.
>
> That Thomas Hawksley, Esq., and G. P. Bidder, Esq., be the engineers associated with Mr. Bazalgette for the purpose stated in the foregoing resolution.

After some further correspondence, in the course of which the Government Referees gave additional explanations respecting the construction and mode of action of their

proposed outfall sewers, Mr. Bazalgette and his coadjutors proceeded to consider the subject, and reported fully thereon to the Metropolitan Board of Works on the 6th of April 1858.

As their Report virtually settled the system which was ultimately carried out, and into the working of which the present inquiry is directed, it is desirable to state its reasonings and conclusions somewhat fully.

### The Report of Messrs. Bidder, Hawksley, and Bazalgette, 1858.

43. The Report was divided under ten heads, viz.:

I. and II. Preliminary and historical.
III. Examination of the Report of the Government Referees.
IV. General observations upon the sewage and rainfall.
V. Area to be drained.
VI. Condition of the river.
VII. Internal drainage.
VIII. Outfalls proposed by the writers.
IX. Expense of other outfalls.
X. Conclusions.

44. Passing over the first two heads, the *Examination of the Referees' Report* was directed chiefly to the outfall sewers and the proposed reservoirs for feeding them with dilution water.

The writers said:

> One of the principal objects of the Referees has been the attainment of outfalls at a considerable distance from the metropolis. No practical engineer acquainted with the valley of the Thames can fail to see the difficulties which are involved in this project. The construction of outfall works for the drainage of a *low* district by *gravitation* to a *remote* point, when the only obtainable fall is a portion of the difference of level between high and low water marks, is only possible at an enormous sacrifice of time and money; nor would the matter be ultimately much improved in its pecuniary results if the aid of machinery were wholly or in part resorted to. The small declivity of the channel incident to great length also necessitates large dimensions, and these again involve a proportionately large outlay. Excessive cost is indeed an inseparable and wholly unavoidable incident of all such structural operations.
>
> The several plans of the Referees amply demonstrate that they have encountered all these difficulties, together with others peculiar to the case, created by themselves. Having determined to recommend points of discharge below Gravesend no less than 23 miles from the head of their outfall sewers on either side the Thames, it became necessary, in order to carry out the principle of drainage by gravitation, aided by dilution, to make large portions of these channels of more than EIGHT times what would have been the required capacity, upon any reasonable calculation, for the drainage of an enlarged metropolitan area extending to Hanwell and Richmond, as they estimated such area would be populated 40 years hence.
>
> The stream of water adequate to give to these sewers the hydraulic depth requisite to insure a sufficient velocity to keep them in a working state is only provided by nature on a very few days in the year, and frequently not for several successive months. The Referees were consequently forced to impose upon themselves the additional difficulty of suggesting reservoirs at the head of each of their outfall sewers in order to supply the deficiencies in the rainfall, and to provide the water necessary to secure the requisite velocity. These reservoirs, as we shall hereafter show, involve not only additional complexities and difficulties, but, even if practicable, they would entail such enormously enhanced first outlay and subsequent annual cost as to render the project extremely objectionable, if not wholly abortive.

They then went into a detailed examination of the Referees' plans; and the following extracts may suffice to show their opinion:

> Without saying that these works are absolutely impracticable, *i.e.*, that money, time, and skill, may not surmount the difficulties incident to them,—yet their execution must be attended with the utmost uncertainty, both of time and cost.
>
> * * * * * * *
>
> From the foregoing description it is obvious that the works proposed on both sides the river, even by the modified scheme of the Referees, are of a magnitude and character wholly unexampled.
>
> * * * * * * *
>
> Looking to all the foregoing considerations; to the enormous and uncertain cost necessarily attending the execution of such works; to the destruction of property they would involve; to the great annoyances and inconveniences that would be occasioned to the population on the lines of the sewers, both during and after their construction, and to the large annual cost of clearing them from deposit, we feel that an overwhelming case of necessity must be established to justify the adoption of a proposal of this description.

45. *The General Observations upon the Sewage and Rainfall* were largely occupied by a controversy as to the gaugings.

Messrs. Bidder, Hawksley, and Bazalgette objected to the large quantities which the Referees had provided for passing off, which they considered prodigious and astounding, and altogether unnecessary. They still maintained that, according to Mr. Bazalgette's plans, the quantity of rain water proposed to be removed would occasion storm overflows into the Thames upon only a very few days in the year.

In regard to the *Area to be drained*, the engineers objected to the extension proposed by the Government Referees, as one which was not only unnecessary, but would, if attempted, result in difficulties of an engineering and monetary character of the most formidable kind.

In regard to the *Condition of the River*, the engineers expressed their conviction that the influence of the sewage on the physical and hygienic condition of the Thames had been much mistaken, and greatly exaggerated.

They considered that the tidal scour, the land floods, and the agitation by steam-boats, were more influential contributors to the existing appearance of the river than the sewage; and that the disgusting effluvia, so much complained of, arose from deposits on filthy mud banks, rather than from the water.

On this account they recommended the embankment of the river in conjunction with the diversion of the sewage.

The chapter on *Internal Drainage* has but little to do with the present object.

46. The eighth chapter, on *The Outfalls proposed* by Messrs. Bidder, Hawksley, and Bazalgette, is so important in regard to the present inquiry that a large portion of it should be quoted here:

In discussing "the condition of the river," we have prepared the Board to anticipate that we have come to a clear and decided opinion that the remote outfalls proposed by the Referees are unnecessary for effecting the objects of the 135th section of the Metropolis Local Management Act. Our own experience had informed us, not only that it is extremely undesirable, in a sanitary point of view, to cause sewage matter to become intermixed with sea-water, and especially under circumstances which will occasion it to be brought up the river by the flood tide, but that, if the sewage matter were poured into a much larger volume of fresh or freshened water, in a flowing stream, it would become immediately oxygenized, and cease to exist as a noisome and offensive agent. The experiments of Dr. Letheby and Dr. Odling have fully confirmed our views.

We have, therefore, unhesitatingly selected for recommendation, as points of outfall, places situated in approachable situations, as near as possible to the metropolitan boundary, and as far as possible from human habitations. Barking Creek on the north side, and Crossness Point on the south side, fulfil all the favourable conditions that are attainable on either side of the river. Both are situated in low and dreary marshes, where neither the works nor the sewage can give reasonable cause of offence to any one. Barking Creek is about 2 miles from Woolwich, and about 4½ miles from Erith. Crossness Point is midway between the two places, and about 3¼ miles from each. The mean sectional area of the river at these places is *four times as great as at London Bridge*, and the average volume of tidal water, *about* 400 *times as much as the volume of the sewage water to be admitted into it.*

The river is fresh, or nearly so, at low water and only moderately mixed with salts of marine origin at high water; more so, it is true, than we could wish; but much less so than at any point lower down the river.

These now suggested points of outfall contrast favourably with the outfalls which have recently been much under discussion and are popularly known as B* (B star). The B* outfall on the north is situated at the mouth of Rainham Creek, and on the south at a point of the river about a mile above the town of Erith. These points of outfall were, as we understand, recommended to the First Commissioner of Works by Captain Burstal, R.N., whose conclusions, as stated in a letter to the Right Hon. Sir Benjamin Hall, under date 18th November 1856, were arrived at from observations made on the river with floats. Upon these conclusions the First Commissioner suggested to the Metropolitan Board the points of outfall recommended to him by Captain Burstal; and the Metropolitan Board, desiring, as before mentioned, to meet the views of the Government, adopted the points so recommended. Appended to another communication from Captain Burstal to the Government Referees, dated 10th July 1857, is a note referring to diagrams showing the results of the experiments with floats. With respect to reasoning upon these diagrams, it may firstly be observed that any views that are not based upon a knowledge of the deodorising effects of air and water upon sewage must necessarily be empirical. But it is not needful at present to consider this part of the question, for the fact is that the diagram embodies, as it appears in the Referees' *Report*, an error which is fatal, not only to the diagram, but to any theory the Referees may have built upon it. * * * We exhibit in the Appendix to this Report a diagram which exemplifies, in colours, the extent of the errors induced.

With respect to the outfalls at B*, it should also be observed that those points are 3½ miles below the metropolitan boundary on the north side, and 2½ miles on the south. The additional cost which such extensions would involve would amount to not less than three hundred and fifty thousand pounds, exclusive of any increased pumping power and reservoirs they might render necessary. Beyond expressing an opinion that the sewage water may be delivered at B* under such circumstances as will render it inappreciable at Erith to every ordinary sense, as well as to the most elaborate chemical inquiry, we have little to observe with respect to these points of outfall. They will undoubtedly answer the proposed purpose, but certainly not so well, either in a sanitary or in a pecuniary view, as points situated higher up the river.

There is, however, this special reason to be urged against placing the outfalls below the metropolitan boundary, to which it may be useful to advert. Mr. Bazalgette, in one of his communications to your Board, has already shown that for many miles there are no points below the metropolitan boundary so remote from habitation and population, and, therefore, so well fitted for points of outfall, as the points close to the boundaries of the metropolis itself. At these points the banks of the river for several miles are low, marshy, and uninhabited; but beyond these points towns and villages on the river side become more frequent. Thus, whilst—

| | |
|---|---|
| The distance from Woolwich to Erith is | 6 miles |
| From Erith to Purfleet it is only | 2 „ |
| „ Purfleet to Greenhithe | 3 „ |
| „ Greenhithe to Grays Thurrock | 2 „ |
| „ Grays Thurrock to Northfleet | 1½ „ |
| „ Northfleet to Gravesend | 1½ „ |

So that, if it were desired to avoid the proximity of an outfall to population, otherwise than by going to an extreme distance, the best points at which to place them are, not at B*, where they would be near to Erith, but at points higher up the river, and nearer to the metropolitan boundary, where they would be about midway between Woolwich and Erith, and at least three miles from both.

Apart from the chemical, economical, and sanitary grounds on which we prefer outfalls situated at the points mentioned, we may pertinently observe that many difficulties will be encountered by attempting to obtain a more remote outfall. The necessary declivity of the sewer will soon bring it to a level at which it cannot empty itself *at any period of the tide.*

This is a very serious consideration, whether in regard to the making or repairing the channel, or in regard to cleansing it from the deposits brought down by the flood waters. Moreover, a sewer so constructed will either drain all the adjacent wells of their spring water or feed them with sewage water, according as the water naturally stands in the wells above or below the water in the sewer. At Gravesend, for example, either of these results would prove a serious evil. Unless also a large sum were expended in making the sewer of great diameter, and in providing a correspondingly increased flow of water through it, the necessary inclination would bring the outfall to so low a level as to necessitate the aid of much pumping machinery.

We are, indeed, of opinion that, if the local circumstances favoured such an arrangement, it would be preferable to place the outfalls within the metropolitan boundary rather than without it, especially on the south side of the river, where a very eligible situation presents itself in the Greenwich marshes, not far from the terminus of the river branch of the North Kent Railway. We believe this point is sufficiently far down the Thames to effect all sanitary objects connected with the river, and we are quite sure that, if the sewage water were discharged below low water mark, and at a suitable period of the tide, its presence would not be observed in the river, either at Woolwich or below. If this arrangement could be effected, a large expenditure, otherwise to be incurred in carrying the outfall sewer through the centre of the town of Woolwich, and to a point five miles lower down the river than the Greenwich marshes, would be saved. The terms of the Metropolis Local Management Act appear, however, to preclude the possibility of effecting such an arrangement.

Assuming, then, that the points we have indicated will find favour with the Board and receive the approval of the First Commissioner of Public Works, it remains only to describe the arrangements which we advise to be adopted for effecting the discharge of the sewage, not merely under the most favourable conditions, but under such circumstances as ought, in our opinion, to preclude the possibility of reasonable objection by other parties locally interested. We are convinced that the sewage might, in regard to health, be safely emitted at all periods of the tide; but, as in this case, some part of it would be washed up the river with the flowing tide, though certainly in an oxygenized, and, therefore, innocuous condition, we propose to construct reservoirs into which the sewage should be received for the purpose of being sent down the river during the first two and a half hours of the ebb tide. We propose, also, that these reservoirs shall be arched and turfed over, so as neither to permit the escape of effluvia, nor present an unsightly appearance.

On the north side the quantity of sewage to be received will amount to about 14,000 cubic feet per minute for six hours of the day, and to about 4,700 feet per minute, on the average, of the remaining 18 hours. The area of the reservoir should be about 12 acres.

On the south side, for the like periods, the respective quantities of sewage will be about 8,000 feet and 2,700 feet, and the area of the reservoir about seven acres.

On the north side the low level sewage will be raised at Abbey Mills by mechanical power to a height of about 34 feet, and will thence flow, by gravitation, into the reservoir; and on the south side the whole of the sewage will be similarly raised into the reservoir near the outfall from a depth of 25 feet.

It is also proposed that in both cases the sewage should be discharged into the river through submerged pipes, terminating below low-water mark.

The reservoirs are proposed to be constructed so as to enable the precipitation of the sewage matter to be effected by the application of lime. We have twice visited Leicester to see the process in operation, and have examined the state of the water, both immediately on quitting the works and after admixture with about twice its own volume of other water in the river. We can speak positively to the fact that the process is most successful; the water is completely deodorized, as well as rendered bright and tasteless. It does not subsequently become putrescent, although diluted with only twice its bulk of other water; both fish and vegetation have returned to the river within a short distance of the works, and the workmen at the water mills on the stream have recovered their health, which had previously been seriously affected by the foul condition of the river, and now state they have nothing to complain of, even in the hottest months of the year.

We do not, however, believe this process to be needed for the prevention of injury to the Thames, or to the health of the population residing on its banks; and we certainly do not recommend it for adoption, because, when produced in large quantities, the precipitated matter is unsaleable, and must be removed at considerable expense.

An objection has been made that the admission of sewage water into the river will be liable to create shoals in the navigable channel. It is scarcely worth while to argue this point, because the sewage matter emitted from the large sewers in London does *not* produce shoals, nor, in fact, can it, especially when, as in the case before us, the detritus of the roads will be detained, and removed, before the water is allowed to pass into the reservoir, and because sewage deposit, being nearly of the same specific gravity as water, is most easily moved by water, and is, moreover, always undergoing the process of destructive decomposition. We have, therefore, no hesitation in stating our decided conviction that shoals will not be created by the admission of sewage water into the Thames in the manner proposed.

47. The estimate of the cost of the works, according to the plan recommended, was stated at 2,300,000*l.*; and under the ninth head, the engineers estimated the further cost of carrying the sewage of the metropolis beyond the points recommended by them, at the following amounts, namely—

| | £ |
|---|---|
| To the points called B* - - - - - - - | 350,000 |
| To the points of outfall midway in Sea Reach - - - | 2,950,000 |

48. The *Conclusions* may be given verbatim:

First. As to the condition of the river:

That the causes of the apparent impurity of the river have been greatly exaggerated and much misunderstood; we find—

1. That the mechanical discoloration of the water is not due to the presence of sewage matter, but chiefly to the presence of inorganic substances brought down by land floods, or washed up and kept in motion by the tide.
2. That the chemical condition of the flowing water is not sensibly altered by the admission of sewage, because the organic matters become rapidly decomposed and disinfected by the action of the oxygen contained in the water through which they are diffused.
3. That mud containing much organic matter, derived in great measure from the sewage discharged above low-water mark, is deposited on the foreshores of the river and there putrifies.
4. That the condition of the flowing water of the river is not injurious to health, but—
5. That the condition of the stagnant mud is injurious to health.
6. That the offensive matters deposited with the inorganic mud are principally derived from the metropolitan sewers, and not, to an appreciable extent, from any more distant sources.
7. That the discharge into the river of comparatively small quantities of sewage matter from areas difficult to drain to any common outfall may be continued by outlets extended to low water without any sensible injury to the appearance of the river or its banks, or any detriment to the health of the inhabitants of the metropolis.
8. That the proper remedies for the evils arising from the present state of the river are two:
   1st. The interception of the greater part of the sewage of the metropolis above the present outlets, and its removal to, and discharge at, parts of the river below London, where its presence will be harmless;
   2nd. The construction of terrace embankments on both sides of the Thames to confine the tidal channel, accelerate the velocity of the stream, and prevent the exposure of the bed and banks of the river.

Secondly. As to the Scheme submitted by the Government Referees:

That the plan recommended by the Referees is needlessly large, excessively costly, and, as a work of construction, all but impracticable; we consider it especially objectionable in the following particulars:—

1. Because the amount of rainflow proposed to be carried off (two-fifths of an inch in eight hours, or six-fifths of an inch in 24 hours) is much greater than is requisite for the *reasonable* purification of the river.
2. Because the internal sewers necessary for the reception of the above amount of rainflow would be extremely difficult to construct under the streets and buildings of the metropolis, and would entail much loss and inconvenience to the inhabitants.
3. Because, although the peculiar arrangements of the Referees have been professedly made with a view to insure the dilution of the sewage to the extent of six times its maximum flow, yet that many of the most populous parts of the metropolis, in which the largest amount of dilution is necessary, are proposed to be provided for to only a much smaller extent.
4. Because, with the object of increasing the extent of the gravitating area, the Referees have adopted lower levels and smaller inclinations than are in practice found to be advantageous.
5. Because no means are suggested for obtaining the stated amount of dilution *within* the metropolis (but only *without* the metropolis), although rainfalls of the amount necessary for cleansing the enlarged sewers will occur only at distant intervals.
6. Because the outfall channels are of enormous size, and would be extremely difficult and expensive to construct in the stated situations and at the stated levels.
7. Because the outfall channels commence at five and four feet respectively below *low-water* mark, and discharge at 17 and 16 feet respectively below *low-water* mark, and consequently cannot be drained off.
8. Because these drowned channels and their open outfalls will accumulate deposits which it will be extremely difficult, and very expensive, to remove.
9. Because the water to be applied for dilution of the outfall channels will re-act on the internal drainage, and pen it back to its own level.
10. Because the cost of the proposed works will, upon any one of the three plans, very greatly exceed the amount at which they are estimated by the Referees, the probable cost of the smallest project being upwards of 9,000,000*l.*

Thirdly. As to the Scheme of the Metropolitan Board:

That the plan already adopted by the Board, with the modifications hereafter mentioned, is adequate to the satisfactory drainage of the metropolis and the reasonable purification of the river and its banks, and is also capable of effecting the following improvements, and of affording the following facilities:—

1. The removal of the maximum sewage water of 3½ millions of people.
2. The removal, in six hours of maximum sewage flow, of a rainflow equivalent to one-fourth of an inch per diem (produced by a rainfall of four-tenths of an inch per diem) from the area to become hereafter occupied by the above amount of population.
3. The relief of the low-lying districts from the effects of ordinary floods and tide-locking.
4. The delivery of the sewage and rainflow at points on the river where they will not be injurious to the health of the inhabitants of London, or of the population residing on the banks of the Thames, or be prejudicial to navigation.
5. The substitution of covered sewers for several of the existing open sewers.
6. The construction of the works at a reasonable cost (2,300,000*l.*) and in a reasonable period of time (5 years).
7. Facilities for treating the sewage with lime or other chemical agents with a view to its defecation before admission into the river, or to the realisation of its fertilising contents, if such should hereafter become commercially valuable.
8. Facilities for discharging the sewage at any (the most desirable) period of the tide, and for securing its transmission in an innocuous condition to the sea.

Fourthly. The modifications we recommend for more perfectly effecting the foregoing and other objects are chiefly the following:—

1. That the northern outfall channel shall discharge at Barking Creek in preference to any lower part of the river.
2. That the southern outfall channel shall, for the purpose of more completely complying with the intentions of the Metropolis Local Management Act, and without, at the same time, giving just cause of offence to the inhabitants of Woolwich and Erith, discharge into the river near Crossness Point; although, in our opinion, a situation equally eligible in every practical point of view presents itself in Greenwich Marshes, near the terminus of the branch line of the North Kent Railway.
3. That covered reservoirs of moderate size be formed near each outlet for the reception of the sewage water until it shall be discharged during the first hours of the descending tide, or to enable it to be defecated by lime or other chemical agent.
4. That the northern outfall sewer be constructed in brickwork rather than in iron, as designed by your engineer, and that a carriage road of 40 feet in width be formed over it.
5. That the dimensions of the southern outfall sewer be somewhat increased in size for the purpose of adding about 4,000 feet per minute to its capability of discharge.
6. That the outfalls of the few outlying sewers which cannot be reasonably brought within the major scheme be advanced into the river, so as to discharge below low-water mark.

49. In an Appendix the engineers added the following remarks:

*Deodorization.*—We have ascertained from the facts collected by us at Leicester and elsewhere that the cost of precipitation by means of lime amounts to 500*l.* per annum in respect of each million of gallons daily operated upon, and that the resulting product is commercially valueless. The sewage due to the present population of the metropolis, including some rainflow, amounts to about 80,000,000 gallons per diem. The cost of the application of the lime process to this quantity of sewage would therefore be 40,000*l.* per annum; but, as in the case of the metropolis there is clearly no advantage, practical or theoretical to be attained by the use of this process during the six colder months of the year, we estimate the extreme cost at only 20,000*l.* per annum. If, however, the sewage be discharged, at Barking Reach and Crossness Point, into deep water, and with the earlier portion of the descending tide, we believe the process will not be needed during even the hotter months, except, perhaps, under very occasional and very exceptional conditions of the river.

*Utilization of Liquid Sewage.*—We have been compelled to consider this question in connexion with the Referees' Report, and, being personally acquainted with most of the practical applications of town liquid, as at Edinburgh, Mansfield, Rugby, Croydon, and other places, come to the following conclusions:—

Firstly. That the fertilizing properties of the organic matters contained in town refuse are for the most part destroyed by the long continued action of water.

Secondly. That the cost and difficulties attending the application of liquid sewage in large quantities are absolutely prohibitory of its use.

Thirdly. That liquid sewage cannot in general be used with advantage in this climate, except in particular states of the weather, and in certain stages of the growth of the crops to which it is applied.

Fourthly. That commonly the distribution of liquid sewage is accompanied by a noisome odour, and, except in the case of its application to sandy or rocky soils of considerable inclination, is liable to induce the worst forms of marsh malaria.

Fifthly. That the proper distribution of the liquid sewage of the metropolis would require an area larger than that of the whole county of Rutland.

The Report was accompanied by several illustrative documents, the most important of which for the present purpose is a "Report of Henry Letheby, Esq., M.B., F.L.S., &c., on chemical and sanitary inquiries into the matter of the main drainage of the metropolis," dated March 15th, 1858. Dr. Letheby summed up his results as follows:—

The conclusions, therefore, at which I have arrived after a careful consideration of all the facts which I have been able to collect in respect of this subject are—

1st. That the turbidity of the river is not caused by the sewage which flows into it, but by the disturbance of the mud upon its banks, for within certain limits, the farther we go down the river, and away from the influence of the sewage, the greater is the turbidity.

2d. That there is no satisfactory evidence to prove that the *soluble* organic matters of the London sewage, when discharged into the Thames, do any serious injury to the river, or to the public health; for, although they reach the Thames in a highly putrescent form, yet such is the influence of dilution, agitation, and oxidation, that their putrid property is quickly lost.

3d. That the mischief which really results from the present mode of disposing of the sewage is caused by the *insoluble* organic matters which collect upon the banks of the river near to the sewers, and there undergo perpetual putrefaction.

4th. That this may be obviated by defecating the sewage by means of lime, and allowing the clear liquor only to be discharged into the Thames; or by discharging the sewage into the Thames in such a manner that it will mix with and be diluted by 200 or 300 times its bulk of water.

And lastly. That the most effective means of improving the condition of the river and of protecting the public health is the embankment of the Thames; for the removal of the offensive mud and the submerging of the river's banks are, in my opinion, the most important of all considerations.

50. On the 7th July 1858 Captain Galton and Mr. Simpson sent to the First Commissioner a reply to Messrs. Bidder, Hawksley, and Bazalgette's Report, which they commenced with the following complaint:

The question under discussion is so important that it is to be lamented that the Metropolitan Board of Works did not refer its consideration to an unbiassed tribunal; and we regret that Mr. Bidder, Mr. Hawksley, and Mr. Bazalgette, have, in their report, misrepresented our statements, and have founded upon these misrepresentations arguments adverse to our conclusions.

They defended their former propositions at considerable length; but it is only necessary to extract some of their conclusions, referring to the propositions of the Metropolitan Board's engineers.

That the limited provision for rainfall in the sewers proposed by Messrs. Bidder, Hawksley, and Bazalgette, would cause the sewage too frequently to overflow into the Thames within the metropolitan district.

That the proposition to throw the whole sewage of the metropolis in a concentrated mass into the Thames at Barking, close to the metropolitan boundary, would not prevent the sewage from returning within the metropolitan limits, and would be injurious to those eastern districts of the metropolis which lie adjacent to the Thames, the population of which is rapidly extending in consequence of the great increase of the commerce of the port of London.

That the embankment of the Thames is desirable as a means of preventing deposits of mud on the foreshores, but it will not effect the purification of the river.

This was replied to by Messrs. Bidder, Hawksley, and Bazalgette, on the 20th July; a rejoinder appeared on 16th August, and the controversy (which had taken a somewhat acrimonious and personal tone) was closed by a letter from Mr. Bidder. dated 20th September 1858.

### State of the Thames, 1858.

51. During the discussions and disputes that were taking place on the main drainage system the state of the Thames was becoming daily much worse, and was exciting great alarm and indignation. The subject was repeatedly noticed in Parliament, and strong language was used in both Houses.

In the House of Commons, on 11th June, Mr. Brady said, "it was a notorious "fact that hon. gentlemen sitting in the committee rooms and the library were utterly "unable to remain there in consequence of the stench which arose from the river."

On 15th June Mr. Mangles said: "By a perverse ingenuity one of the noblest of "rivers had been changed into a cesspool;" and, on the 17th, Mr. Palk described it as "one vast sewer, which would surely spread disease and death around." On the 18th a long debate took place on what was termed "the pestilential condition of "the Thames," and "the vile state of that magnificent river."

Similar complaints were made in the House of Lords. On 25th June the Earl of Hardwicke said the Thames had been "made the main sewer for the whole of London, "and had been converted into a most abominable ditch." "The gaseous matter "flowed along with the river, and at high water the state of the atmosphere was "worse than at any other time of the tide." Earl Grey said it was impossible that "such a stench should not be exceedingly dangerous."

The result of this agitation was that, as a temporary measure, the Government sanctioned a series of remedial operations by mixing lime with the sewage before its discharge into the river. This was carried on by the Metropolitan Board at a large expense for a considerable time.

### Alteration of the Law, and Construction of the Main Drainage Works, 1858–1875.

52. The Metropolitan Board received the report of Messrs. Bidder, Hawksley, and Bazalgette, at the beginning of April 1858, but they delayed its consideration for some time, and the main drainage appeared to have come to a deadlock.

Meanwhile there had been a change of Government. In February 1858 Lord Palmerston went out of office, and the Earl of Derby became Prime Minister; and, as a consequence of this, the office of First Commissioner of Works was transferred from Sir Benjamin Hall to Lord John Manners.

In one of the debates on the state of the river in the House of Commons, on the 18th June 1858, the former gentleman, now in opposition, complained of the Metropolitan Board having let the whole summer pass without any care for the state of the Thames or the condition of the inhabitants of the metropolis. He added:—

He thought that the time had now come when the Government should consider whether it would not be better to take the whole of this great work into their own hands; whether they should not appoint some Commission of able and responsible persons, subject, of course, to the approval of the Treasury, and leave it to them to carry out both the main drainage of the metropolis and the embankment of the Thames, works of such magnitude that it was impossible that they could be paid for wholly out of local rates.

This notice appears to have stirred the Metropolitan Board to action, for, on the 29th June, they passed a resolution approving the main features of Messrs. Bidder, Hawksley, and Bazalgette's scheme, and appointed a deputation to submit it to the new First Commissioner.

The interview took place on the 1st July. The chairman described the nature of the works proposed, and proceeded to point out some of the difficulties which impeded

the free action of the Board, in consequence of the Act of 1855 rendering it imperative that their designs should be approved by the Government, a condition from which they wished to be relieved.

The change of Ministry brought with it a change of policy in regard to this matter. The party formerly in office had firmly adhered to the principle that the Government had a right to be consulted on a measure of such public importance as the drainage of the metropolis; but the new Administration held a different view, and the result was that on the 15th July the Chancellor of the Exchequer (Mr. D'Israeli) moved for leave to bring in a Bill the object of which was to relieve the Board of Works from the necessity of Government sanction, on the ground that, as the metropolis paid for the work, they had a right to construct it in any way they pleased; or, as the First Commissioner afterwards expressed it, "He who pays the fiddler has a right to call the tune."

The proposal was received with much criticism. The discussions on the subject had become widely known; the subject was warmly taken up, and stormy debates occurred at every stage of progress of the Bill in both Houses; but the views of the Government ultimately prevailed, and the Bill became law on the 2nd August 1858.

53. This Act, 21 & 22 Vict. cap. 104., was entitled "An Act to alter and amend "the Metropolis Local Management Act (1855), and to extend the powers of the "Metropolitan Board of Works for the purification of the Thames and the main "drainage of the Metropolis."

It repealed the obnoxious provisions of the former Act, and substituted the following:—

I. The Metropolitan Board shall cause to be commenced, as soon as may be after the passing of this Act, and to be carried out and completed with all convenient speed, according to such plan as to them may seem proper, the necessary sewers and works for the improvement of the main drainage of the metropolis, and for preventing, as far as may be practicable, the sewage of the metropolis from passing into the River Thames within the metropolis.

Borrowing powers were given to the extent of 3,000,000*l.*, and the time for executing the works was extended to the 31st December 1863.

The Board were also bound to avoid causing any nuisance, and were liable to indictment in case of the infringement of this provision.

54. It certainly appears somewhat remarkable that the Legislature should have withdrawn all control over the construction of gigantic works of this kind, which were certain to have influences of a wide national character. But, if the debates which occurred at the time are carefully studied, it is not difficult to trace out the reasons which mainly influenced the decision.

In the first place, the state of the river urgently called for immediate action in some way or other. Your Majesty's gracious speech at the close of the session said, "The sanitary condition of the metropolis must always be a subject of deep interest "to Her Majesty, and Her Majesty has readily sanctioned the Act which you have "passed for the purification of that noble river, the present state of which is little "creditable to a great country, and seriously prejudicial to the health and comfort "of the inhabitants of the metropolis."

Secondly, all the contending parties, whose opinions were of any value, agreed that the general principle proposed by the Board, namely, that of intercepting the sewage by main conduits which should carry it away to the eastward, was the correct one to be applied.

Thirdly, in the wide divergence of opinion as to the disposal of the sewage and the points of its discharge into the Thames, it was felt to be impossible for Parliament to undertake the decision between the conflicting views. But it was clearly seen that in any case the carrying out of the intercepting system would be a necessary preliminary measure, and might therefore safely be entered upon at once, leaving the ultimate mode of disposal of the sewage for later decision. In other words, it was considered that the plans of the Board were not necessarily final, but might be extended and amended at a future time, if need should arise. The following extracts will illustrate the views entertained on this point:—

Sir John Shelley said,—

There was nothing in the plan now proposed, he believed, to prevent the sewage being ultimately carried to Sea Reach, if it should be found necessary.

Mr. Lowe said,—

It might be found necessary, after all, to send the sewage down to Sea Reach.

Viscount Palmerston said,—

Complete relief would not be afforded to the metropolis by the expenditure of 3,000,000*l.*, and if tunnels [main sewers] were constructed to Barking Creek, the Metropolitan Board of Works would have to come to Parliament and say, "You sanctioned this work, but by limiting the expenditure you forced us to adopt a "plan which is essentially and radically defective, and therefore, on the part of the public, we call upon you "to assist us by grants of public money to carry the sewage to another point."

Mr. Robert Stephenson said,—

Whether or not it might be necessary hereafter to go down to Sea Reach, was not a question for the House now to decide. Meanwhile, let them be contented to go down to Barking Creek. For his part, he thought it important not to go too far down the river in the first instance. * * * Even supposing they finally carried the outfall down to Sea Reach, much in a monetary point of view would be gained by not adopting that plan in the first instance. Moreover, he believed that sewage matter would eventually be made useful for agricultural purposes, and he therefore thought it impolitic to enter into any larger expenditure than could well be helped for the present, if even it were found necessary to carry the sewers down to Sea Reach hereafter.

Lastly, there was a confident expectation that, although the sewage would be discharged in the first instance at what was considered by many to be an objectionable point, it would be treated by some process of deodorization before entering the Thames. The following extracts from the debates show this:—

Lord John Manners said,—

He thought the Metropolitan Board of Works had done wisely and well in determining that, should they fix on the points of outfall at Barking Creek and Crossness Point, they would deodorize the sewage there during six months in the year.

Mr. Tite said,—

The evidence clearly showed that, if they deodorized the sewage, it mattered little at what part the sewage water was turned into the river. Therefore it would be unnecessary to continue the limits within which the outfalls were not to be made.

Mr. D'Israeli said,—

We make it a condition with the Metropolitan Board of Works * * that provision shall be made for such temporary and *permanent* works of deodorization as the metropolis has a right to require.

Mr. Lowe said,—

The plan of the Metropolitan Board of Works was that the sewage * * should be discharged into a reservoir at Barking Creek * * whence, having undergone a process of deodorization by lime, it should be discharged into the Thames.

Sir John Shelley said,—

It was hardly fair that * * that process was insisted on during only six months.

Mr. Robert Stephenson—

Quite admitted that some parts of the metropolis could not be drained except by deodorization.

Mr. Akroyd—

Objected to the scheme of deodorizing only for six months in the year, as the sewage thus poured out in the winter months would form mud banks which would ferment and poison the atmosphere in summer. They ought to insist upon deodorization for the whole year.

Mr. Pullen said,—

In the report of the Committee of the House on the subject it was stated that no plan ought to be regarded for the sewage of the metropolis which did not provide for one of two things; either that it should be taken down the river so far from the metropolis that it could not be brought back by the action of the tide, or else that it should be deodorized, and only the purified liquid part of it discharged into the river.

The Earl of Derby said,—

It is generally understood, although there is no express provision in the Bill to that effect, that the *modus operandi* is to be by intercepting sewers, whereby the sewage of the metropolis will not be allowed to be poured into the river until it shall have undergone, at such place or places as may be determined on, the process of deodorization.

It has also been shown by the extracts we have given from Messrs. Bidder, Hawksley, and Bazalgette's Report, (paragraphs 46, 48, and 49), and by the evidence before this Commission, QQ. 8622 to 8626, that some process of deodorization before discharge was originally contemplated by the Metropolitan Board as a possible necessity, and for which accordingly some provision was made.

55. Immediately after the passing of the Act the Metropolitan Board took the matter earnestly in hand. The designs were speedily completed, and contracts were entered into for the construction of the works.

In 1863 these had so far advanced as to admit of temporary arrangements for the discharge of a portion of the northern sewage at Barking. The northern and southern

outfalls were both completed and in use in 1864. At that date the Board calculated that nearly one third of the metropolitan sewage had been diverted, and the diversion resulted immediately in a greatly improved state of the river within the metropolitan area.

In 1865 the works were still further advanced, and the great drainage system was formally "opened" by H.R.H. the Prince of Wales on the 4th of April in that year.

There still, however, remained some important parts incomplete, the chief of which were the great low-level sewer on the north side (which was delayed by the construction of the Thames Embankment, of which it formed a part), and also some large pumping stations. These took some time, and it was not till the year 1875 that the works were pronounced complete.

Subsequently to the commencement of the works a considerable change had been made in their extent by the addition of what is called the "Western Division," including Fulham, Chelsea, Brompton, Kensington, Shepherd's Bush, Hammersmith, and part of Acton. The Board originally intended to deodorize or utilize the sewage of this district in its own neighbourhood, rather than incur the costly process of carrying it to Barking, and lifting it twice on its route to that place. But on further consideration, and in deference to the wishes of the inhabitants and others, they subsequently adopted the latter plan, and included it in the northern low-level system of metropolitan drainage.

## Enlargements found Necessary, 1881–2.

56. In the report of the Metropolitan Board for 1881 occurs the following passage:—

> The floodings from heavy storms of rain which have occurred on several occasions in recent years in some of the populous suburbs of London, principally those on a low level, made it necessary for the Board to determine upon the construction of some additional large sewers to carry off the storm water. The new sewers which the Board, after careful consideration, resolved to construct were these—
>
> 1. Storm relief line for the Ranelagh and King's Scholars Pond Sewers.
> 2. Storm relief line for the Ratcliff Highway and Limekiln Dock Sewers. Relief line for high level sewer at Hackney.
> 3. Intercepting sewer from Putney to Clapham. Storm relief to high level sewer at High Street, Clapham, to discharge into Effra Creek, Vauxhall.
> 4. Deptford storm overflow.
> 5. New sewer from Deptford Broadway to Lee Bridge.
> 6. Sewer to relieve low-lying ground at Walworth.
> 7. Storm sewer to relieve Holloway and Kentish Town.

These sewers will have storm outlets into the Thames. Sir Joseph Bazalgette gives (QQ. 26 to 34) further particulars about them, and states that their cost will be 1,500,000*l.*

The same report also says:—

> The Board has lately resolved to enlarge the reservoirs at the Barking and Crossness outfalls to about 50 per cent. beyond their present capacity, so as to admit of the largely increased quantity of sewage being stored in the reservoirs until the ebb tide, instead of, as has occasionally been necessary, having to be discharged on the flood tide, and thus giving rise to complaints that the Thames water at Woolwich was rendered impure. The specification and drawings of the works are in course of preparation.

Sir Joseph Bazalgette gives (Q. 76) further explanations about these reservoir enlargements, and estimates their cost at 160,000*l.*

## The Thames Embankment, 1860–1874.

57. It had been agreed on all hands that, in conjunction with the diversion of the sewage, it would be desirable to carry out plans which had been proposed at an early period for the embankment of the Thames through the metropolis. The offensive state of the river had been greatly enhanced by large areas left dry at low water, on which sewage matter collected and putrefied; and the proper way of removing this cause of mischief was by confining the current within a narrowed channel.

In 1860, and again in 1861, public inquiries were undertaken on the subject, and, after some discussion as to the manner in which the work should be constructed, an Act was passed in 1863, entrusting its execution to the Metropolitan Board. This was followed by other Acts. The work was proceeded with, and was finished about 1874.

## Attempts to Utilize the Sewage, 1860 to 1873.

58. Soon after the Metropolitan Board had begun the main drainage works, they took up the question of the possibility of utilizing the sewage of London.

At that time considerable differences of opinion existed as to whether sewage could be profitably applied to land on a large scale, and the Board considered that their best course was to get private enterprise to aid them in effecting the object. With this view, in the beginning of 1860, they issued public advertisements inviting proposals for taking the sewage. Several answers were received and discussed, but as in the meantime Parliament had taken up the general subject, the Board determined to wait the result of their inquiry.

In 1862 a committee of the House of Commons was appointed, on the motion of Dr. Brady, to inquire "into the best means of utilizing the sewage of the cities and "towns of England." Their report was laid before the House in July 1862, and was generally to the effect that the value of the sewage varied greatly under different circumstances, but that municipalities had not sufficient powers for its most profitable application.

The Board again advertised early in 1864, hoping, as they said, that some plan would be produced whereby "a remunerative profit would be afforded to the pro- "jectors, and some pecuniary means provided for the reduction of the burthens of "metropolitan taxation, thereby assisting the Board to carry out many works of "public improvement urgently required in the metropolis."

More plans were sent in, and a decision was about to be made, when, in April 1864, Lord Robert Montagu obtained the appointment of a second committee in the House of Commons to investigate the matter. The report of this committee was much more positive than the former one, as they expressed an opinion that it was not only possible to utilize the sewage of towns by conveying it in a liquid state through pipes to the country, but that such an undertaking might be made to result in pecuniary benefit to the ratepayers of the town whose sewage was thus utilized.

On this, the Board sent a deputation to visit some towns where sewage irrigation was applied, and, being then convinced that the time for action had arrived, they resolved to accept one of the offers submitted in answer to their advertisements, namely, that of Messrs. Hope and Napier.

59. These gentlemen proposed to construct works for enabling them to take the dry weather sewage of the northern area of the metropolis, and to conduct it by a conduit some 40 or 50 miles long down to the Maplin Sands on the Essex coast, where it was to be applied to the reclamation and irrigation of a large tract of land. Powers were also to be taken to supply sewage to the country all along the line of conduit. A company was to be formed, with a capital of 2,100,000*l.*, and the profits were to be divided between it and the Metropolitan Board.

Messrs. Hope and Napier introduced a Bill into Parliament which was opposed and discussed in Committee, but was ultimately passed on the 19th June 1865, and the Company was formed under the name of "The Metropolis Sewage and Essex "Reclamation Company."

Doubts having been expressed by Baron Liebig and other scientific men as to the feasibility of the scheme, the Company, in order to afford a practical test of its merits, took, in 1866, a large piece of land at Barking, and established there a model sewage farm, supplied directly from the northern metropolitan outfall sewer. The results of this trial were reported as very satisfactory.

It was stipulated that the main conduit to the Maplin Sands should be finished within four years after the passing of the Act. It was commenced towards the end of 1865, but the operations upon it soon ceased, and in 1866 the Company obtained an amending Act extending the time of completion till July 1876.

In the session of 1871, nothing more having been done, the Metropolitan Board promoted a Bill in Parliament for setting aside the arrangement, and at the same time the Company introduced a counter-Bill, to enable them to modify their proposed plan of operations. The House of Commons rejected both Bills, thus leaving the matter where it was before. No further notice has been taken of the subject in the reports of the Metropolitan Board.

60. In regard to the sewage from the south side of the metropolitan area, several offers were received and considered at various times, but no agreement was come to.

In 1870 the attention of the Board was called to the method of sewage treatment adopted by the Native Guano Company, commonly called the A. B. C. process. They visited the Company's works at Leamington, and, after some negotiation, they assented to a proposal of the Company to put down, at their own expense, experimental works at Crossness, to show how they could deal with the sewage discharging there.

The trials were begun in August 1872, and lasted till the end of November in that year. The Company treated about $\frac{1}{343}$ part of the whole Crossness sewage, and they produced a large quantity of solid manure.

The experiments were carefully watched by the engineering and chemical officers of the Board, who reported fully on them in January 1873. It was recorded that the condition of the effluent water was found to be, on the whole, very good, and no offensive effluvia or nuisance resulted from the preparation of the manure.

But when the financial part of the proceeding was examined, the Board came to the conclusion "that there was no proof that the process could be adopted with any "hope of profit to the rate payers," and as this hope of profit appeared to be their only inducement for defecating the sewage, they dismissed the Company, and made them at once remove their works and plant from the ground.

## Former Public Inquiries as to alleged Evils resulting from the Sewage Discharge.

61. There have already been two public inquiries on this subject, which it will be convenient briefly to notice.

### *Mr. Rawlinson's Barking Inquiry*, 1868.

The discharge of sewage at the Barking outfall commenced in 1863, but it was not till 1865 that the works were formally opened and the full quantities of sewage were discharged.

The outfall had not been long in use before complaints arose. In May 1868 a memorial was addressed to the Home Secretary from the inhabitants of Barking, calling attention to the condition of the Thames in consequence of the discharge of sewage through the main outfalls.

The Home Secretary, after communicating with the River Conservancy and the Metropolitan Board, ordered an inquiry, which (after some delay caused by a change of administration) took place at Barking in June 1869, the officer appointed to hold it being Mr. (now Sir) Robert Rawlinson; C.B., Chief Engineering Inspector to the Local Government Board.

The inquiry lasted five days; the memorialists and the Metropolitan Board were represented by counsel, and many witnesses were examined, among whom were, for the former, Capt. Burstal, Mr. Leach, and Mr. Hope; and for the latter, Messrs. Bazalgette, Bidder, Hawksley, Gregory, Hawkshaw, Haywood, Hemans, Dr. Miller, and Dr. Odling.

Mr. Rawlinson made his report in November 1869, and it was afterwards published as a Parliamentary Paper (No. 7 of 1870).

The memorial alleged, in substance, that the river was silting up to such an extent as to be dangerous to navigation, and that its pollution was dangerous to the health of the inhabitants of Barking and of all the populous towns below London.

The inquiry took a wider range than was anticipated, and Mr. Rawlinson's conclusions were as follow:—

That the allegations in the memorial have only been partially proven.

That the memorialists are not in a position to establish deterioration of health to emanations from the metropolitan main sewerage outfall works, as the town of Barking is without local governing powers, is unsewered, contains many cesspools, a sewage-tainted sub-soil, and has a defective water supply.

That the River Thames is polluted by the metropolitan sewage and receives such road and street detritus as the aforesaid sewage contains.

That the main channel of the Thames has not been reduced in depth of water by such detritus.

That Barking Creek has not been closed to vessels of 250 tons burden.

That fish have been destroyed in the creek, but most probably by chemical refuse.

That an accumulation of mud has taken place, both on the shore of the Thames and at the mouth of Barking Creek, but from what special cause has not been proven.

That the Metropolitan Board of Works, in their annual reports, recognize their obligation to purify the Thames, and to effect this purpose have negotiated with second parties for the utilization of the northern sewage by irrigation.

That the Board, throughout their transactions for the utilization of sewage, have stipulated for pecuniary relief to the metropolitan ratepayers.

That the Metropolitan Board have objected to the admission of sewage into the Thames from towns situate above London, and, therefore, inferentially justify the objections to river pollution below London.

That deodorization and disinfection of the metropolitan sewage, by chemicals, would be very costly to the ratepayers, and in the results imperfect.

That river pollution by town sewage, in the case of the Thames, may be prevented.

The following additional extracts from the report will be useful as showing the opinions which Mr. Rawlinson was led to form by the evidence laid before him :—

The complex questions of tidal flow and of scour, of the accumulation of mud banks in specified parts, and of the weight of detritus brought from the metropolitan road and street surfaces, mixed with the sewage and discharged into the Thames, I cannot pretend to settle There are, however, the simple facts that all town sewage does contain certain proportions of solids, which solids can neither be oxydized nor annihilated; and, therefore, however small or however large in quantity they may be, if turned into the Thames, they must ultimately deposit somewhere. There is also the additional fact that the London sewage is discharged into the Thames, with whatever detritus there may be, just as it flows down the main sewers. It was contended by the engineer to the Metropolitan Board of Works that streets and roads within the metropolitan area are far better scavenged than those in provincial towns, such as Birmingham, and that all the detritus which can be retained is regularly emptied from the numerous gullies, or is raised by hand from the tributary sewers. Admitting the general regularity and perfection of London street and road scavenging, yet very dirty (muddy) streets are seen occasionally, and no mechanical arrangements of gulley catchpits can prevent some of this mud and detritus flowing with the vast volume of sewage to the outlets.

* * * * * *

The evidence given at the inquiry is clear and distinct that the navigation of the Thames has not been endangered; there is no loss of water in the main channel; neither do the engineer nor secretary to the Thames Conservancy Board anticipate damage to the low water main channel; the movement of steamers up and down, with the scour of the tides and land floods, being sufficient to keep the waterway open; any extra deposit of silt is on mud banks and the shores betwixt low and high water.

No medical proof was given by evidence that the health of the inhabitants of the parish of Barking and other populous and industrious towns below London suffered in consequence of the discharge of sewage through the metropolitan main sewerage outfall works. The men and their families situate at and over these works, it was stated, do not suffer specially.

* * * * * *

The banks and shores of such tidal estuaries are constantly altering by this unceasing scour, and there is as constant a redeposit of the sand and mud from the flood and tidal waters, so that it would be very difficult to define (legally) where any increase of deposit has come from, in the Thames at Barking. There is, however, the simple fact that *all the detritus* brought down by the metropolitan sewers, much or little, passes, at present, with the sewage direct into the River Thames; and that portion of detritus which is not soluble in water must be deposited, part on the shores in the mud found there, and part on the estuary banks;—annihilation is impossible.

* * * * * *

The purification of the Thames is of the utmost importance; the task of its accomplishment, as imposed by Parliament, rests upon the Metropolitan Board; and negotiations with private companies, if they fail, cannot free the Board from this responsibility. If the works can be executed without loss, the metropolitan ratepayers have a right to be exonerated from any charges; if there accrues an income above a stipulated percentage, they ought to share the profits; but if the work of freeing the Thames from pollution can only be accomplished by a rate in aid, it is the duty of the Metropolitan Board to meet this difficulty, and to levy such rate as may be required.

* * * * * *

The Metropolitan Board have evidently fettered themselves throughout with striving to obtain what they consider the full value of the sewage, when this ought to have been a secondary consideration, prevention of pollution to the Thames being the first consideration.

* * * * * *

With respect to the existing sites of the outfalls at Crossness and Barking, * * * all things being considered, I think no more appropriate places could be found, if sewage irrigation is ultimately to be carried out. The entire works have been well executed in every respect.

* * * * * *

The mud found on the banks and shores of the Thames in Barking Reach, upon analyses by Drs. Miller and Odling, is found not to differ in its chemical elements from Thames mud generally, as deposited on the shores of the river from Teddington to Erith.

* * * * * *

If, hereafter, Parliament enacts that rivers shall not continue to be polluted by town sewage (and the Thames is not exempted), ways to complete sewage irrigation works must and will be found. The manurial value of town sewage has over and over again been settled by the most eminent chemists, and the practicability of using it in agriculture, beneficially, is year by year being tested and proved.

### *The Thames Conservancy Mud-bank Inquiries*, 1867–80.

62. Although the complaints of the inhabitants of Barking had been shown to be, in a great measure, groundless, they were not the only parties who were alarmed about the state of the Thames, as the subject had attracted the attention of the body most especially interested in the river, namely, the Thames Conservancy Board.

This body had for some time been making surveys and observations on the bed of the river, and in 1867 and 1868 chemical analyses had been made for them by Dr. Letheby of the constituents of the mud collecting near the outfalls. Immediately after the appearance of Mr. Rawlinson's report they gave notice of a Bill in Parliament,

one of the objects of which was to prevent the Metropolitan Board of Works from discharging from their outfalls without previous deodorization. The Bill was strongly opposed by the Metropolitan Board in committee, and the result was a compromise, the Bill being allowed to pass in an altered form. It was called the "Thames Navigation Act, 1870," and contained the following provision:—

XX. The Metropolitan Board of Works shall, at their own expense, keep the Thames free from such banks or other obstructions to the navigation thereof as may have arisen or may arise from the flow of sewage at their outfalls for the time being into the river. And, for the purposes aforesaid, the said Board shall have full power and authority from time to time to dredge the said river, and to remove such banks or obstructions; but all such dredging operations shall be subject to the approval of the Conservators, and, if they so require, be carried on under their superintendence.

Section XXI. provided that, if any difference should arise as to the origin of any banks or obstructions to the navigation, it should be determined by arbitration.

In 1873 further analyses were made, and in July 1874 the Thames Conservators formally complained to the Metropolitan Board that increase of deposit was forming in the bed of the river near the outfalls. The Board disputed the fact, and some further correspondence ensued.

In 1875, 1876, and 1877, the analyses were repeated by Dr. Letheby and Professor Williamson, and in June of the latter year the Conservators instructed Captain Calver, R.N., F.R.S., to make an examination of the river bed, its shoals and deposits, and the way in which these were affected by the discharge of the metropolitan sewage; also into the changes in the channel, and the question of sewage and river currents.

Upon these points Captain Calver, on the 15th October 1877, made a long report to the Conservators, the conclusions at which he arrived being mainly as follows:

That offensive accretions had recently formed within the channel of the Thames; that a material portion of these were in the neighbourhood of the sewage outfalls, and had formed since the outfalls came into operation; that the constituents of these accretions were the same as those of the sewage, and that the latter was discharged in sufficient quantity to account for them, the tidal streams in the neighbourhood of the outfalls being the effective cause. He further expressed the opinion that the increase of soil in Woolwich Reach and elsewhere above the outfalls had been derived from the sewage discharge, and that the operation of accretion had been effected by the superior disturbing and transporting power of the flood stream.

The Conservators sent this report to the Metropolitan Board, and requested them to carry out the terms of the Act. The Board, on this, directed its engineering and chemical officers to institute an inquiry into the facts, and in April 1878 a report was made by Sir Joseph Bazalgette, Messrs. Law and Chatterton, and Messrs. Keates and Dupré, strongly challenging the statements of Captain Calver in every particular. Replies and rejoinders followed, but as no agreement appeared possible, in 1879 the Conservators determined to appeal to the powers of the Act of 1870; and in the middle of that year it was arranged that an arbitration should take place, under the 21st section of that Act, to try the question.

It was decided at the outset that the inquiry should be entirely confined to the origin of three particular banks in the river, near the outfalls (called Margaretness Bank, Barking Bank, and Crossness Bank respectively), and as to their being obstructions to the navigation; and that the question of the pollution of the river by the flow of sewage at the outfalls should not be gone into.

The arbitrators sat twenty-five days, between November 1879 and March 1880, and made their report on the 24th April 1880.

They took a great deal of evidence in regard to the sewage question generally, and they determined—

1. That the banks in question had not obstructed the navigation further than by making the main channels somewhat more crooked.
2. That they had arisen from the effect of dredging operations.
3. That the water in the tidal portion of the Thames contained a considerable amount of suspended matter, derived partly from the basins of the Thames and its tributaries, partly from the washing away of the foreshores of the tidal estuary where unprotected, partly from material brought up from the mouth of the river by the flood tide, partly from sand and mud stirred up in the course of dredging operations, partly from denudation of the river bed, partly from sewers in districts outside the metropolitan area, and partly from the sewers of the Metropolitan Board. The proportion contributed from this latter source was small as compared with the total amount of suspended matter in the whole volume of tidal water flowing past the outfalls on every tide.

4. That the three banks were composed of matter which had been held in suspension in the water, and had been derived from the several sources above-mentioned. Whilst, therefore, the sewage from the metropolitan outfalls might have contributed to their contents, the three banks could not be said, in the sense of the Act of 1870, to have arisen from the flow of sewage at the outfalls; and the Metropolitan Board should not be called on to remove or contribute any portion of the expense of removing them.

# PART II.

## THE SYSTEM UNDER WHICH SEWAGE IS DISCHARGED INTO THE THAMES BY THE METROPOLITAN BOARD OF WORKS.

63. The system of the Metropolitan Main Drainage, as actually carried out, has been fully explained to us by Sir Joseph Bazalgette; and before offering any remarks on it we may give a brief description of its more important features.

### General Principle.

64. The general principle of the Metropolitan Main Drainage System is that of *interception*.

According to the natural hydrographical features of the district, the portion of the Thames Basin on which the metropolis stands is drained by transverse streams flowing into the river on each side; and the sewers, which have been formed from time to time to effect the artificial drainage, have been made to follow the lines of these streams.

In order, therefore, to prevent these sewers from discharging into the river, the principle has been adopted of *intercepting* them by lines of conduits lying nearly at right angles to them, *i.e.*, in the same general direction as the course of the river, but inclining towards it. These conduits fall in an easterly direction, and are continued down to points on the banks of the river below London, where the sewage, intercepted and carried off by them, is discharged.

In such of these intercepting conduits as are at sufficient altitude, the sewage flows away by gravitation. But as many parts of the metropolis lie so low as to render this impossible, the contents of the intercepting conduits there have to be pumped up by steam power, in order to raise them to the necessary level of discharge.

The entire system (which is shown on the map marked Appendix B.) is naturally separated into two great divisions, lying on the north and south of the river respectively.

### Northern Interception.

65. On the north side there are three great lines of interception;—

1. A line called the *Northern High Level Sewer*, which, beginning in the north-west at Hampstead and Highgate, passing by Hackney, descending by Stratford, and crossing over the River Lea near Bow, abuts upon the Thames at Barking Creek. This conduit acts entirely by gravitation.
2. A line at a lower level called the *Northern Middle Level Sewer*, which begins in the west at Kensal Green, passes through Oxford Street, Clerkenwell, and Bethnal Green, and joins the Northern High Level Sewer near Bow. This conduit also works entirely by gravitation.
3. A line at a still lower level called the *Northern Low Level Sewer*. It begins in the extreme west at Chiswick, and passes through Chelsea, near the bank of the river, as far as the Grosvenor Road, Pimlico. Here, near the Victoria Railway Bridge, its contents are pumped into another conduit lying slightly higher, which runs along the northern Thames embankment, and near the river to the Tower, then striking off to the north-east through Stepney to Abbey Mills, near Stratford, where the contents are again pumped up to the level of the Northern High and Middle Level Sewers.

From this point the whole of the northern drainage flows through the *Northern Outfall Sewer* to the Thames; this outfall sewer is formed of three parallel conduits, which take the contents of the three sewers, but can be made to communicate when necessary to equalise the flow.

## Southern Interception.

66. On the south side of the river there are two great lines of interception,—

1. A line called the *Southern High Level Sewer*, which begins at Balham and passes through Clapham, Brixton, Camberwell, and New Cross, crosses under Deptford Creek by iron syphon pipes, and continues through Greenwich, Woolwich, and Plumstead Marshes to a pumping station on the right bank of the river at Crossness. The sewage reaches that point by gravitation.
2. A line called the *Southern Low Level Sewer*. It begins in the extreme south-west at Putney, and passes through Wandsworth, Battersea, Vauxhall, Kennington, Peckham, and New Cross, to a pumping station on the Ravensbourne, near Deptford, where the contents are pumped into the Southern Outfall Sewer.

At a certain point near Nine Elms there is a pumping station, which lifts into this sewer the drainage brought down by the sewers on the River Effra.

There is also a branch conduit from the districts of Bermondsey and Rotherhithe, which delivers to the Deptford pumping station, the contents being then pumped into the Southern Outfall Sewer.

From Deptford the united sewage flows down to Crossness by the *Southern Outfall Sewer*.

At Crossness the whole is pumped by steam power to the height necessary to allow it to flow into the river.

67. The following data furnished by Sir Joseph Bazalgette (see Q. 12,502) will give a general idea of the magnitude of the works:—

| Areas from which Sewage is intercepted. | | | | Length of Main Intercepting Sewers, including Branches. | Dimensions, Largest and Smallest. | Inclinations, Greatest and Least. |
|---|---|---|---|---|---|---|
| North Side of Thames. | Inside Metropolis. | Outside Metropolis. | Total. | | | |
| | Square Miles. | Square Miles. | Square Miles. | Miles. | | Feet per mile. |
| High Level | 8·29 | — | 8·29 | 7⅓ | 9′ 6″ × 12′ 0″ Barrel – 4′ 0″ | 75 to 4. |
| Mid Level | 16·47 | Kilburn 1·34, S. Hornsey 0·37 = 1·71 | 18·18 | 12¾ | 10′ 6″ Bl. – 4′ 0″ × 2′ 8″ | 17½ to 2. |
| Low Level, including Western Division | 23·74 | — | 23·74 | 21 | 10′ 3″ Bl. – 3′ 9″ × 2′ 6″ | 10·37 to 2 |
| Outfall Sewer | — | — | — | 5½ | 3 Culverts, 9′ 0″ × 9′ 0″; 2 Culverts, 9′ 0″ × 9′ 0″ | 2. |
| | 48·50A | | 50·21C | 46¾ | | |
| Area of Metropolis [North] *not* drained into intercepting sewers. | 1·47B | | | | | |
| | 49·97 | | | | | |

A. Of this area 3·40 square miles is common or park land, and 0·87 square miles is water.

B. This area consists of parts of Hackney Marshes, North Woolwich, and a detached part of the Metropolis near Muswell Hill.

C. In addition to the above, the district of the Hornsey Local Board contributes sewage from a present population of about 22,000, the quantity being restricted ultimately to 500 cubic feet per minute. A part of the Stamford Brook drainage area contributes also the sewage from a small population, but its number cannot be ascertained. The same area also contributes surface water to the Metropolitan system, but the Metropolitan Board have determined to intercept this from their sewers and discharge it into the river at the extreme western boundary of the Metropolis. This is one of the works included in the 1,500,000*l.*, to be expended to prevent floodings from rain.

| Areas from which Sewage is intercepted. South Side of Thames. | Inside Metropolis. | Outside Metropolis. | Total. | Length of Main Intercepting Sewers, including Branches. | Dimensions, Largest and Smallest. | Inclinations, Greatest and Least. |
|---|---|---|---|---|---|---|
| | Square Miles. | Square Miles. | Square Miles. | Miles. | | Feet per mile. |
| High Level | 24·71 | Upper Norwood, 0·54 | 25·25 | 14⅝ | Two 10′ 6″ × 10′ 6″ - One 3′ 0″ × 2′ 0″ - | 52·8 to 2½. |
| Low Level | 20·72 | | 20·72 | 14⅛ | Two 7′0″ × 7′0″ One 4′ 0″ Bl. - | 4½ to 2. |
| Outfall Sewer | 5·78 | | 5·78 | 7½ | 11′ 6″ | 2. |
| | 51·21D | | 51·75F | 36¼ | | |
| Areas of Metropolis (South) *not* drained into intersecting sewers. | 16·57E | | | | | |
| | 67·78 | | | | | |

D. This contains 3 square miles of common land and park, and 0·56 square mile of water.

E. This contains ½ square mile of common land and parks, 3½ square miles of marsh lands, 2·15 square miles draining away from the Metropolis, and the rest in land of a rural or agricultural character, situate in the localities of Roehampton, Eltham, and Mottingham, which will never probably be more than sparsely built over.

F. In addition to this, 0·92 square mile of Beckenham contributes sewage only to the intercepting system.

PUMPING STATIONS.

| | Total Nominal Horse Power. | Lift. |
|---|---|---|
| | | Feet. |
| For Northern Sewage. | | |
| Pimlico | 480 | 18 |
| Abbey Mills | 1140 | 36 |
| For Southern Sewage. | | |
| Deptford | 500 | 18 |
| Crossness | 1000 | 10 to 30 |
| For Storm Relief Overflows. (South Side only.) | | |
| Effra | 200 | 5 to 18 |
| Falcon Brook | 200 | 3 to 10½ |

## Arrangements at the Main Outfalls.

68. The outfall sewers do not discharge directly into the Thames; they terminate in large covered reservoirs, from which the sewage is intended to be discharged only at certain times of the tide. The discharge commences at high water, and it was intended, according to the report of Messrs. Bidder, Hawksley, and Bazalgette, to have been completed "during the first two and a half hours of the ebb tide." As a matter of fact, however, it usually continues for three or four hours, after which time it is intended that the Penstocks are to be closed, allowing the sewage to collect in the reservoirs for discharge on the next tide.

The reservoir at Barking Creek covers about 9½ acres, and holds 35,000,000 gallons, or 5,600,000 cubic feet. That at Crossness covers about 6½ acres, and contains 25,000,000 gallons, or 4,000,000 cubic feet. (In the report of Messrs. Bidder, Hawksley, and Bazalgette, it was recommended that the area of the Barking Reservoir should be about 12 acres, and of that at Crossness about 7 acres.)

The bottoms of the reservoirs are 2·75 feet above ordnance datum, or 1·19 feet above half tide level. At the top they are provided with overflow weirs, from which, when the reservoirs are full, the sewage passes into the river.

At Barking the overflow weirs are at the height of 16·25 feet above ordnance datum, so that the available depth is 13·5 feet. At Crossness the weirs are 2·5 feet higher, giving an available depth of 16 feet.

The works are so constructed that at Crossness the discharge is always below water; but at Barking this is not the case, the discharge partly taking place over the foreshore. The latter arrangement is a departure from the condition laid down

in Messrs. Bidder, Hawksley, and Bazalgette's Report (see *ante*, par. 46) that "in "both cases the sewage should be discharged into the river through submerged "pipes, terminating below low-water mark."

The sewers are capable of bringing down much more than the reservoirs will hold, and when they do so, there will be an overflow into the river from the reservoirs at any time of the tide, as at the storm outlets.

At the beginning of 1881, there were overflows on 43 days from Crossness, and more days at Barking. (See Q. 74.)

It was intended (see Q. 158) that the reservoirs were to be added to from time to time, and it is admitted by the Metropolitan Board that the period has now arrived when more storage room is necessary.

## Capacity of the Main Sewers for Discharge.

69. The capacity of the main intercepting and discharging conduits, as compared with the drainage requirements of the district, involves complicated considerations, in consequence of the double nature of the work to be done.

The drainage of a thickly inhabited area requires the removal, not only of the sewage from the houses, or what may be called the *sewage proper*, but also of the *rain* which falls over the whole area.

70. It has often been proposed to deal with these two elements independently, by establishing a *separate system* of drains for each. This system presents many and great advantages both as regards the removal and the disposal of the sewage proper. It was strongly recommended to the Government by a member of this Commission, in the year 1868, for application to certain towns on the Upper Thames, and it has been carried out at Eton, and in other places, with perfect success and with great benefit.

It was proposed for London in 1854 (as already mentioned in the Historical Notice); but in dealing with such an immense area it has been considered hardly practicable. Sir Joseph Bazalgette says (Q. 9):—

"There are 400,000 houses in London, and the adoption of such a plan would involve redraining every one of these houses. You must put a drain into the house to take the sewage from the waterclosets and the sinks, in fact, from the inside of the house, and you must carry the water from the roof by another drain, separating the two from each house from the very commencement. Now, putting that reconstruction of all the drains of all the houses at 20*l.* per house upon the average, would make 8,000,000*l.* to begin with in the house drainage. Then it is not merely a question of money, but I think you would have a very powerful resistance to any such proposal. I think that every house in London having to be redrained would both on account of the expense and of the immense disturbance that would arise from it, be very strongly objected to. Then that is not all. You would have to use the present system of sewers for the storm water, and to lay an entirely separate set of sewers through the streets for the sewage, with pumping establishments, and so forth. That, we came to the conclusion, could not be done, that, as applied to London, it was an impracticable suggestion."

71. The designers of the London main drainage had therefore to undertake the problem of combining the removal of the sewage and the rainfall in one system, which would have the advantage of using the rain and storm waters to effect the flushing out of the sewers. But they were met by the difficulty that, while the sewage was a comparatively small and a tolerably uniform quantity, the rainfall was a very excessive and a very variable quantity.

Sir Joseph Bazalgette states (Q. 8) that, whereas the maximum flow of the sewage proper of London is not equivalent to a rainfall of $\frac{1}{100}$th of an inch per hour over the whole drainage area, the rainfall amounts sometimes to one, two, three, or even four inches per hour over parts of London.

Further data as to these quantities will be found in the evidence; it may suffice here to state the general principle on which the design was made, and that is given concisely by Sir Joseph Bazalgette in Q. 9. He says:—

"It appeared from tables of rainfall that there were only from 14 to 21 days in the year on which the rainfall exceeded the rate of a quarter of an inch in 24 hours; therefore, we said, if we can divert the sewage from the river in dry weather altogether on all those days excepting the 14 to 21, according to the season (a very wet season has been 30 days), we shall sufficiently divert the sewage from the river to make it clear."

72. The average quantity of sewage actually discharged has been in round numbers as follows, in millions of gallons per diem :—

| — | Crossness. | Barking. | Total. | — |
|---|---|---|---|---|
| 1869 | 48·2 | 35·2 | 83·4 | System incomplete. |
| 1870 | 45·9 | 40·0 | 85·9 | |
| 1871 | 50·8 | 55·0 | 105·8 | |
| 1872 | 61·0 | 63·2 | 124·2 | |
| 1873 | 60·0 | 62·0 | 122·0 | |
| 1874 | 56·0 | 61·9 | 117·9 | |
| 1875 | 64·5 | 74·0 | 138·5 | |
| 1876 | 61·5 | 76·0 | 137·5 | |
| 1877 | 71·2 | 82·2 | 153·4 | |
| 1878 | 74·8 | 82·7 | 157·5 | |
| 1879 | 85·1 | 92·1 | 177·2 | |
| 1880 | 80·9 | 88·8 | 169·7 | |
| 1881 | 74·6 | 89·4 | 164·0 | |

The volumes which the outfall sewers are said to be calculated to carry are—

| | Cubic feet per second. | Millions of Gallons per day. |
|---|---|---|
| For the North - - - | 545 | 294 |
| „ South - - - | 233 | 126 |
| | 778 | 420 |

## Storm Overflows.

73. It is a consequence of the system adopted that there are certain times in the year when the rainfall is so great that the total quantity flowing off must exceed the discharging capacity of the intercepting conduits; and at these times there is no alternative but to allow the superfluous quantity to be discharged directly into the river, independently of the interception, and at the old points of discharge within the metropolitan area.

Suitable arrangements are made for this purpose. The sizes of the intercepting sewers being graduated to take the calculated quantity, at the points of interception of each of the original sewers there is formed a long weir; and when the rain exceeds the calculated quantity, the surplus contents of the sewer flow over this weir and follow the former course down the original sewer, from the mouth of which the fluid escapes directly into the river.

There are 48 of these storm or relief outlets within the metropolitan area, 35 on the north side and 13 on the south. A list of them, showing their positions and dimensions, is given by Sir Joseph Bazalgette in Q. 12,728; they are generally of large size, capable of delivering large discharges when they come into action.

For the prompt relief of certain low-lying districts the storm discharge is aided by steam power. On the banks of the Effra at Nine Elms there is a pumping station of 200 horse-power for lifting the storm waters into the river, when they are penned up by the tide. There is another at the Falcon Brook of the same power.

It is obvious that the fluid discharged from these storm outlets does not consist merely of rain water, but must contain a mixture of sewage.

The present relief by storm overflows is not found sufficient, and very large extensions are now in progress, as explained in the Historical Notice.

## Cost.

74. The total cost of the Main Drainage works hitherto has been stated in the Reports of the Metropolitan Board to be about 4,600,000*l.*

The cost of the further relief works and extension of the reservoirs is estimated at about 1,650,000*l.* more; which will bring the total expenditure to 6,250,000*l.*, as against the original estimate of Messrs. Bidder, Hawksley, and Bazalgette, of 2,300,000*l.*, and of the Referees' alternative scheme of 5,437,000*l.*

## Remarks.

75. The historical notice we have given will show that the Drainage System was decided on under great difficulties, the differences of opinion as to some of the principles of the scheme being very formidable. It became, therefore, an arduous task to settle the plans to be adopted, but the state of the river rendered a prompt decision necessary, and it cannot be questioned that the Metropolitan Board of Works had good grounds for the course they took in the matter. The arguments in favour of a larger scheme, with more distant outfalls, were urged with much force, and by very competent authorities, but the Board had to consider the important conditions of promptness of execution and economy of cost; and as they had reasonable justification for believing in the sufficiency of the scheme they adopted, they cannot be blamed for declining to commit their constituency to what they thought an unnecessary expenditure; especially as an extension of the outfall sewers to a lower point, if necessary, could always be effected at a future time. And, having once decided on their plans, the energy shown in carrying them out with all expedition is deserving of great credit.

To their engineer also, who has been fortunate enough to see the great work carried through from its inception to its successful completion, high praise is due. It is true that the main features had been proposed before he took charge of the work, but this fact in no wise detracts from Sir Joseph Bazalgette's professional skill in re-designing the whole scheme, in all its comprehensive details, and in carrying it through all the intricate difficulties of its construction; so making that practical which before was theoretical only. And it must be observed that, whatever differences of opinion may exist as to disputed points in the design of the works, no question has ever been raised as to their excellence of construction.

76. Then, further, no one can deny the great benefit that has arisen from the main drainage works. The discharge of the sewage into the river within the heart of London had become intolerable, and its interception has exercised a powerful influence in improving the general health of the metropolis. For the system has not only removed an offensive and deleterious element from the most populous part of London, but has also promoted general salubrity by improving the drainage of the entire metropolitan area.

And even granting that some evils may be caused, as we think is the case, by the present mode of discharge, yet these are not of a nature to be compared with those that have been removed by the main drainage scheme.

77. The weakest points of the present system are, the necessity for a large provision of storm outlets, and the discharge of the sewage in its natural crude state.

The *Storm Outlets* are a necessary consequence of the limited general capacity of the intercepting system, and of the sewers having to carry off the sewage and the storm water combined. The question of capacity was argued at much length before the present designs were adopted, as will be seen in our historical notice. The Government Referees urged that a larger system would be necessary, but the advisers of the Metropolitan Board considered their proposals needlessly expensive.

The objection to the capacity has been renewed in evidence before us. Some of the complainants' scientific witnesses have expressed the opinion that the provision for interception is too limited, and that consequently the discharges from the storm overflows within the metropolis are already more frequent, and larger in amount than they ought to be; an evil which, if it exists at present, must increase as the population extends.

It is asserted that there is an error in regard to the estimation of the rainfall to be provided for. For even assuming there were only 14 to 21 days in the year in which there was over a quarter of an inch of rain in the 24 hours, there would be more than that number when the rainfall would exceed one-eighth in 12 hours, or one-sixteenth in 6 hours, either of which would tend to produce overflow.

These allegations are denied by the scientific witnesses of the Metropolitan Board, who contend that the system, with the proposed addition, affords ample provision, not only for the present, but also for the prospective drainage

We cannot, however, lose sight of the important fact, that an expenditure is now going on of the large sum of 1,500,000*l.* for additional "relief sewers" with storm overflows discharging within the metropolis.

78. We are of opinion that the discharges of sewage from the storm overflows, within the metropolitan area, are frequent and considerable, and that they are occasionally of very offensive character.

*Mr. Phillips*, formerly surveyor of the metropolitan sewers, states (Q. 6322, &c.) that "there are hundreds of miles of sewers now in the metropolis in which the sewage "does not flow at the velocity ($2\frac{1}{2}$ feet per second) necessary to prevent the sewage "matters from depositing, and which are called deposit sewers." In these and many other sewers large accumulations take place in dry weather; and when sudden heavy rains occur, as in thunder storms, great masses of filthy material are washed out, and, as the intercepting sewers are gorged by the sudden rain, find their way by the storm outfalls directly into the urban reaches of the river.

We have some evidence of this.

*Captain Marsden, harbour master*, says, July 1879, (Appendix N., and Q. 5356, &c.) On approaching the storm outlet at Ratcliff Creek, I encountered a great quantity of sewage matter of the worst possible kind issuing from that outlet. It could not have been worse if we had been in the sewer itself.

The time was just before low water, and as a natural consequence all this excrement would be carried up the river with the flood tide, polluting and being deposited in the higher reaches.

*Mr. Little, Inspector*, says, December 1880 (Appendix N.), The sewers next below London Bridge, at Dowgate, at St. Paul's, at Blackfriars, and the pumping station Grosvenor Road, were discharging very offensive matter into the river on the 6th and 7th instant.

I have observed this on several occasions during the past week, the discharge prevailing from half ebb and on the young flood.

*Mr. Bowen, deputy harbour master*, says, July 1882 (App. N.), As I rowed past the following storm outlets this morning at 10.30, last quarter ebb, viz., Ratcliff Cross, Bell Wharf, and Coal Stairs, I passed through an immense quantity of *bonâ fide* sewage, and the smell from it was most offensive.

*Mr. P. W. Birch, Mem. Inst. C.E.*, says (9292, &c.), On the 22nd October I had occasion to go up Deptford Creek; it was after a considerable amount of rain; I found the storm overflows were at work, and I saw more solid sewage floating upon the surface of the water than ever in my life before. It was apparently the strongest matter in the form of sewage that I have ever seen. I think that must be a serious disadvantage to people having property in the creek.

79. It is probable the noxious matters which these discharges contain are so speedily oxidized and destroyed by the fresh river water as to become inoffensive and imperceptible. But in this process the free oxygen is abstracted from the water, which is thus rendered less capable of acting efficiently on the larger sewage discharges met with below.

It is stated by some witnesses (Dr. Frankland, for example,) that the condition of the river within the metropolitan area is deteriorating every year, and it is also said that certain banks of offensive mud exist even as high as Westminster bridge; but the evidence on these points is not conclusive. Still, however, the storm discharges, as an element of imperfection in the drainage system, cannot be ignored; it is in evidence they are being largely increased, and it must be borne in mind that if the increase goes on as the population extends, they will probably hereafter diminish to a perceptible extent the advantages of the intercepting system.

This condition of things is to be regretted, but though the storm discharges are locally offensive and disgusting at times, there is no evidence of any injury or serious inconvenience resulting from them above the reach of the influence of the main outfalls.

80. The second weak point in the system as now worked is the *discharge of the sewage in its crude state*, without any attempt to render it less offensive by separating the solids or otherwise.

We have shown in the Historical Notice (par. 54) that at the time the Act of 1858 was passed, giving power to the Metropolitan Board to design the main drainage works, it was understood that the sewage (if discharged at what were considered by many to be objectionable points) would, during some portion of the year at least, be treated by some process of deodorization before entering the Thames. That this might have to be done was clearly contemplated in the original scheme, and ministerial pledges were given in Parliament, in the name of the Metropolitan Board, that it should be done.

Probably the chief complaint against the Metropolitan Board is on this ground; but it must be borne in mind that this evil is not inherent in the system, but depends on its management; and the question how far it is remediable belongs more properly to the third head of our inquiry, which we propose to undertake hereafter.

81. There is still an important matter to consider in regard to the present system, namely—

THE DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER.

The quantity of sewage actually discharged into the river at the two outfalls of Barking and Crossness, has amounted, on the average of a few past years, to about 170 millions of gallons a day, or nearly 19,000 cubic feet per minute.

But this discharge varies exceedingly at different times, according to the quantity of rain carried off by the sewers; and it is generally admitted that the quantity of *sewage proper*, that is, the quantity which would flow off from the house and general drainage, without any accidental mixture of rain or spring water, may be fairly measured by the amount of the water supply. This is given in Mr. Baldwin Latham's table, Appendix R., and in the month of September it amounted to about 16,000 cubic feet per minute, or 144 millions of gallons per diem.

In dry weather the whole of this will enter the Thames at the two main outfalls, at Crossness and Barking.

In order to be able to judge of the consequences of this discharge from the great outfalls, it is desirable to consider what becomes of the sewage after it enters the river, and in what manner it may be distributed about by the various hydraulic currents or motions it encounters there. Accordingly this part of the question has received attention on frequent occasions, when the position of the outfalls has been under discussion.

82. The general nature of the problems involved under this head, may be simply explained as follows:

If a particle of sewage be discharged laterally into a flowing stream, not tidal, it is evident that (neglecting the effect of irregular currents) the particle will be carried downwards with a velocity depending on the quantity of water flowing, and the area of the section.

If, however, this particle of sewage be discharged into a tidal estuary, its motion becomes more complicated.

Suppose at first the case of a simple tidal creek, of considerable length, having no influx of fresh water at its head; the particle will acquire a reciprocating or oscillating motion, up and down the creek, with the influx and efflux of the tide.

If the particle be discharged at *high* water, it will descend the creek for a certain distance during the ebb, and when the tide returns it will be carried back again, about to the place it originally started from.

If it be discharged at *low* water, it will, in a similar manner, supposing the creek to be long enough, be carried up by the flood, and returned by the ebb to its starting place again.

If the particle be discharged at an intermediate point of the tidal motion, say, for example, at half ebb, it will first be carried downwards till low water, reaching a point situated at a certain distance below the point of discharge; it will then be carried up by the flood to another point situated at about the same distance *above* the point of discharge, and at half ebb it will have come back again to its first position.

At spring tides, this *tidal oscillation* will be longer than at neaps; and it will follow that during the transition from neap to spring tides, (since the quantity of water entering increases every tide,) the particle of sewage will be carried up a little higher every day.

Suppose now the sewage to be discharged into a tidal estuary, which receives the fresh water of a river at its upper end, as in the River Thames. The discharged sewage will undergo a daily oscillating motion, due to the tide, but it will also be subject to a gradual progress down the river, due to the constant accession of upland water at the head and sides of the estuary, which must ultimately find its way down to the sea. In other words, the tidal oscillation will still continue; but its locality will suffer a gradual movement or *displacement* down stream, the amount of which will be dependent on the quantity of fresh water entering the river.

Another effect follows from the tidal oscillation. Supposing the sewage to be discharged during certain portions of every tide, the effect must necessarily be that the discharge of one day will, to a large extent, mix with the discharges of previous days, and so there will result an *accumulation* of sewage in the oscillation space. The amount of this accumulation will depend on the rate of downward displacement. When little land water is entering, the displacement will be slow, and there may be many days'

accumulation; while in time of land floods the downward progress will be rapid, and the accumulation will be reduced.

The above considerations assume the motions of the water in the river to be regular and simple; but in practice they are not so. They are subject to many irregularities and complications of various kinds, which produce a peculiar effect called the *mixing action*. This is of considerable importance, as influencing materially the distribution of the sewage, and it will be more fully described hereafter.

All the points embodied in the foregoing general statement have been discussed at various times, and a great body of information on them has been laid before this Commission. The Corporation of the City of London have, especially, undertaken a very elaborate series of investigations, for the purpose of illustrating this subject. They will be found described in the evidence of the scientific witnesses, and they throw considerable light on all the points named under this branch of the inquiry; namely, the tidal oscillation, the gradual progression downwards by displacement, and the mixing action.

83. First, as to the tidal oscillation. When Mr. Frank Forster was making his early designs in 1850–1, in order to judge as to the position of his outfalls, he directed some experiments to be made to ascertain the nature of the tidal currents in the river. These experiments were carried out by Mr. Phillips, who has described them in his evidence. (Q. 6357, *et seq.*)

Floats were put into the river at Barking Creek (the proposed point of outfall) at different times of tide, and their positions noted at the extremes of their motion. The general result was to show, first, that the tidal oscillation varied from about 10 to 14 miles in length; secondly, that when the float started from Barking after high water, it was carried by the next flood tide considerably above Barking; and thirdly, that the permanent progression down stream did not exceed five miles in 15 days, *i.e.*, on the average, one third of a mile per diem. As a deduction from the experiments it was stated,—

"That if the sewage be not put into the Thames at Barking Creek at some period earlier than two hours after high water each tide there will always be the certainty of its going up the river as far as Greenwich; and should a long continuation of northerly winds happen just after the times of lowest neaps, there is every probability of its being drawn up as far as Rotherhithe."

Sir Joseph Bazalgette, in his evidence before this Commission, refers to these tidal experiments. He gives (Q. 5) 12 miles as the extent of the tidal oscillation; and he says (Q. 86), "it may be roughly assumed that a substance in suspension works up the "river about one mile a day at each high water as the springs strengthen, and down "the river two miles a day as they fall off." But he does not consider that the motion of a float is analogous to what would take place with the particles of sewage.

Five years later these experiments were checked, at the request of the First Commissioner of Works, by Captain Burstal, who has given the Commission an account of his experiments and his report upon them. (Q. 6485 to 6500, and Appendices C. and L.) He confirmed the accuracy of Mr. Frank Forster's experiments, and added some data as to the set and velocity of the streams and currents in that part of the river, showing that certain circumstances connected with them were favourable to the deposit of matters in suspension.

Captain Burstal also adds (Q. 6427 and 6500) further experiments on the set of the tides.

In 1857 the Government Referees, Messrs. Galton, Simpson, and Blackwell, referred to the experiments of Mr. Frank Forster and Captain Burstal, and to some further float trials made by Mr. Homfray. The conclusions they drew on the subject have been given in the Historical Notice.

A large series of float experiments, made expressly for production before this Commission, are described in the evidence of Messrs. Baldwin Latham and Birch, and graphically delineated in the drawings Appendix T. A special description is also given in Mr. Latham's Report, Appendix R.

Seven distinct sets of observations were made, with large floats specially constructed for the purpose. These floats were put into the river, opposite the northern outfall, at various periods of the tide, and each float was carefully watched and its motions and positions were accurately recorded for many days; some were observed for 45 days, others for more than 30 days, and one for 18 days, all therefore giving a range over both springs and neaps.

There are many anomalous circumstances in the recorded motion of the floats, arising probably from wind, or irregularities in the currents, or other accidental causes; but there is not a doubt of their good faith, and as a whole they bear evidence of trustworthiness, and may be considered as representing what they profess to represent, namely, the actual motion of some portions of the water of the river, in the neighbourhood of the northern outfall, under different tidal conditions. And the rough practical inference may be undoubtedly drawn from the experiments, that where the floats went, sewage discharged from the northern outfall, at the same times of the tide, may also go.

The chief points shown by these experiments are briefly as follows:

1. The extent of the tidal oscillation varied considerably; the variation being due, not only to the character of the tide, but also probably to the position any particular float happened to occupy in the river, some parts of which move faster than others.

2. The maximum range of oscillation recorded, at spring tides, was about 18 miles, the minimum, at neap tides, a little under seven miles; the mean of the whole of the observations gave about 12½ miles.

3. A float which was started from the northern outfall at high water, is said to have ascended, with subsequent flowing tides, to a distance of seven or eight miles *above* the outfall, or to Greenwich.

4. Another float which was started from the northern outfall three hours after high water is said to have ascended, with subsequent flowing tides, to a distance of 20 miles above, or between Putney and Hammersmith bridges.

5. Another float which was started from the northern outfall at low water, is said to have ascended, with subsequent flowing tides, to a distance of 21 or 22 miles above, or between Hammersmith and Chiswick.

The general results of these experiments accord fairly with those formerly obtained, so far as the length of the daily tidal oscillation is concerned, and they add important and novel information as to the distance to which the tidal currents may travel. For it is now evident that, at whatever time of tide the sewage is discharged, some of it may, under certain conditions, be carried up by the tidal oscillation alone into the heart of the metropolis, and even further.

84. The circumstances of the discharge at the metropolitan outfalls are as follows:

The sewage is received into reservoirs having sluices communicating with the river. These sluices are intended to be opened at high water, and to remain open until the quantity accumulated is discharged. The discharge at present takes some three or four hours, but it is sometimes necessary to let out the sewage even during the rising tide. It is admitted that the storage room is inadequate, and the Metropolitan Board are preparing to increase it considerably.

Supposing, however, that the discharge can hereafter be confined to two or three hours after high water, it is obvious that on the return of the tide, the oscillation will still carry a portion of the discharge above the outfalls; for by the time the latter part of the sewage has returned to the place of its discharge, the flowing tide will still have some hours to ascend, and must therefore carry the sewage with it.

Moreover, during the transition from neap to spring tides, the tidal oscillation will increase in length, and consequently the sewage, however discharged, will make its way daily further and further above the outfalls.

It must also be remarked that, if the time of discharge be reduced, the pollution of the river at or near the outfalls will be proportionally augmented during such time. And as the volume cast into the river increases, this evil will obviously increase also.

85. The float experiments give no trustworthy information as to the gradual *displacement*, or progress downwards, of the sewage by the constant influx of fresh water. There has been an impression that float experiments ought to show this, but the resulting movement is so small that it is lost in the numerous irregularities to which the floats are subject in their travel. Hence the data for determining this quantity must be sought elsewhere.

An estimate of it may easily be made by calculation; for, assuming the mass of water at any given place to be pushed bodily downwards by the influx of fresh water above, the mean displacement will be equal to the quantity of the inflow, divided by the area of the section.

Taking therefore the area of section at the outfalls, at mean tide level, at about 50,000 square feet, we have, in order to find the mean displacement due to any influx, to divide the quantity inflowing by this number.

It need hardly be said that the quantity of upland water inflowing varies enormously at different times. The *mean* quantity, above the outfalls, over an average year, may be taken at about 120,000 cubic feet per minute, which would give a displacement near the outfalls of about 2·4 feet per minute, or $\frac{2}{3}$ of a mile a day.

But in heavy floods the influx reaches about 1,500,000 cubic feet per minute, which would give $8\frac{1}{4}$ miles a day.

On the other hand, in dry seasons, the inflow diminishes to about 48,500 cubic feet per minute, which would give a displacement of only a little over $\frac{1}{4}$ a mile a day.

Mr. Frank Forster's experiments, previously quoted, give an average of one third of a mile per day; Sir Joseph Bazalgette appears to have estimated about half a mile.

As the sewage descends the river, its progress will become slower and slower. In mean seasons it would require, on the whole, about 150 days to travel from the outfalls to the sea, if its progress depended on the influx of upland water alone.

·86. It is now, however, necessary to describe, more at length, the peculiar feature already briefly alluded to, namely, the *mixing* action, which has such a remarkable influence on the distribution of the sewage in the river.

When, after low water at the mouth, the tide enters from the sea, a quantity of salt water will of course find its way for a certain distance up the river; but there is no sharp line of demarcation between the salt water that has so entered, and the fresh water that travels down the stream. The change is very gradual, and extends over a long distance. The saltness diminishes as the river is ascended. At the mouth it is somewhat less than that of the sea. Higher up the water becomes brackish, and then gradually passes to the state of fresh water. But the saltness, in some degree, extends to a distance very far beyond that which the sea water would be supposed to travel on purely hydraulic considerations. In the Thames, for example, it is well known that the water is perceptibly brackish a long way above Gravesend, and the presence of sea water can be traced not only through London but occasionally almost up to the tidal limit at Teddington.

This effect is due to a singular process of mixing which goes on between the fresh and the salt water during the tidal movements. There are many causes which contribute to this effect. In the first place, the velocities of the water vary much in different parts of the same section of the river; secondly, the regularity of the currents is largely interfered with by the configurations of the shores and the bed, producing eddies, patches of slack water, reversals of the current, and so on; thirdly, other irregularities are due to the agitation caused by strong winds; fourthly, the sea water, the land water, and the sewage are all of different specific gravities, and consequently tend to occupy different levels; and fifthly, there is a tendency in fluids to mix or diffuse, when brought even into simple contact with each other. All these causes combine to produce a mixing of the sea and land water, to a much greater extent than has hitherto been supposed.

87. The proof of the mixing action, and at the same time the means of its quantitative determination, are furnished by the amount of *chlorine* found in the water; and the scientific witnesses engaged by the Corporation of London have brought this consideration forward very prominently, as a means of throwing light on the distribution of the sewage in the Thames.*

It is argued, and we think correctly, that since a mixing action is known to go on between the sea water and the land water, there is every reason to believe that the same kind of action will go on between each of these and the sewage; and that the chlorine test ought to afford a means of determining the extent of this mixing action, so far as the sewage is concerned.

For example, the chlorine test shows that in the water at Chiswick, at certain times, a quantity of chlorine is found which cannot be traced to any source except the sea; proving, therefore, that by the mixing action some sea water from Southend has ascended to that remote part of the river. But since, in travelling there, it must have passed through the fluid mixture distributed near the outfall, it must have brought with it a portion of the sewer discharge, and hence an extent of distribution is proved which has never been suspected heretofore.

The data for the statements laid before the Commission are derived from the determinations, by Professor Way (since deceased) of the amounts of chlorine contained

* See also the earlier report to the Woolwich Local Board by Mr. Wigner, F.C.S., as to the flow upwards of sea water along the bottom of the river. Appendix O.

in certain samples of water (see Q. 11,286 *et seq.*) taken on certain days at various points of the Thames, from Teddington to Southend. To these are added (see Appendix R.) the known quantities of land water and of sewage entering the river on each of the days in question.

The problem then, is, having given the quantities of chlorine contained in sea water, land water, and sewage respectively, to find the proportion of each in the sample analysed by Professor Way.

This has been solved by Mr. Baldwin Latham, by Mr. Mansergh, by Mr. Birch, by Professor Unwin, by Dr. Frankland, and by Professor Way, each using an independent method; and another independent mode of calculation has been given by the Secretary to the Commission in Appendix A.F. The results are fairly concordant.

Objections have been made both to the data and the calculations founded on them, but we are satisfied that the results throw quite a new light on the distribution of the sewage.

It is now clear that the notion that, by certain arrangements at the outfalls, the sewage there discharged may be made at once to descend the river, and so get away, must be abandoned. For not only is a certain travel up the river produced by the tidal oscillation, but, by the still more comprehensive and extended nature of the mixing action, part of what is discharged from the main outfalls is carried upwards, under certain circumstances, over almost the whole tidal range.

Nobody has hitherto anticipated that liquid discharged into the river at Barking could be transported, by any natural causes, many miles up the river, directly in the face of the powerful descending stream of the land water; but that this effect is produced can no longer be doubted.

We notice, however, that, as might reasonably be expected, the penetration of the sewage liquid upwards is influenced considerably by the strength of the land stream. When the quantity of land water is large the upward travel is much less than when little land water is coming down.

We consider it also proved, by the calculations based on the chlorine test, that the proportion of the sewer-liquid contained in the river in the neighbourhood of the outfalls is, in dry seasons, very large. Some of the calculations profess to show that, in the driest weather, this proportion may possibly approach one-sixth of the whole volume of the river; but we may make a large deduction from this, and still find a startling result.

88. Some misapprehension has often existed as to the extent of the *dilution* of the sewage by its admission into a bulk of water in the river. It is asserted, with truth, that the quantity of water passing the outfalls during the time the sewage is being discharged is some hundreds of times greater than the quantity of sewage it receives, and hence it is argued that the sewage must be diluted to this amount. But this is a fallacy, inasmuch as the water so passing is not pure water; it is water which, by the tidal oscillation, has already become contaminated by the *accumulation* before mentioned, of successive previous sewage discharges. The only true sources of dilution for the sewage are the land water entering above and near the outfalls, and the salt water which finds its way upwards from the sea. It is very difficult to estimate the effect of the latter, as we cannot tell how often it may be changed; but the benefit of the dilution by it is diminished by the fact that the sea water, in its passage up the river, has to meet and mix with the sewage mixture travelling down, which must (except in so far as the sewage has undergone oxidation) contaminate it and diminish its purifying capability.

It is asserted on behalf of the Metropolitan Board that there may be another element of dilution, namely, spring water which may find its way into the bed of the river from the permeable strata around. There appears, however, to be no satisfactory evidence of such accession of any considerable quantity of land water to the river. No doubt the permeable strata in the London basin contain a large store of water collected from the rain falling on the land surface above them; but there is reason to believe that these stores are so drawn upon in the neighbourhood of the river, as to bring the subterranean water level below that of the Thames, which would effectually prevent the spontaneous flow into the river that is relied on by the Metropolitan Board.

89. It has been shown that the mixing action considerably facilitates the permanent progress of the sewage out of the river. Instead of the two-thirds of a mile dis-

placement near the outfalls due to the fresh water alone, in the mean conditions, the mixing action may be stated to produce a permanent displacement of eight-tenths of a mile per day. In dry weather, the sewage discharged at the outfalls gets out to sea, after about 30 days oscillation up and down. It may thus be said that by this natural process of mixing, the sea sends, so to speak, an auxiliary carrier up to the high parts of the estuary to help the land water in bringing the sewage down.

90. There is one respect in which the mixing action is less beneficial, namely, that the combination of sewage with sea water produces less inoffensive compounds than with fresh water. The calculations show that in dry weather at high water (when the sewage is discharged) there is a large proportion of sea water in the river; and it is clear, therefore, that the discharge of sewage into such a mixture must be liable to produce a greater nuisance than if running into a fresh stream.

91. But while we consider that the wide distribution of the discharge from the sewers, and its occasional large proportion in the river, are sufficiently proved, we think that the answer which the Metropolitan Board have put forward to the objections these facts raise to their system is worthy of attention.

They say that the sewage, during its oscillation, travel, and mixing, becomes so quickly oxidised and purified as to lose, almost immediately, all its offensive qualities, and to become as innocuous as the natural water in the river; for which reason these elaborate discussions of the distribution of the sewage have no practical importance.

We shall consider the validity and force of this argument in the following part of our report.

# PART III.

92. We now proceed to the main object of this Report, namely, the consideration—

## WHETHER ANY EVILS RESULT FROM THE SYSTEM UNDER WHICH SEWAGE IS DISCHARGED INTO THE THAMES BY THE METROPOLITAN BOARD OF WORKS.

Five evils have been mentioned as arising, or likely to arise, from this discharge, namely—

(A.) Injury to the Healthiness of the Districts in the Neighbourhood of the River.

(B.) General Nuisance and Inconvenience from the Pollution of the River.

(C.) Injury to Fish.

(D.) Pollution of Wells near the River.

(E.) The Formation of Shoals or Banks which might prejudice the Navigation of the River.

We will deal with each of these in order.

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### (A.)

### Injury to the Healthiness of the Districts in the Neighbourhood of the River.

93. In many of the complaints, a fear has been expressed that the discharge of the sewage has had, or may have, a serious effect on the health of the populations on the banks of the river.

94. We have received much evidence on this point. In addition to general witnesses, we have heard, on the complainants' side,

Mr. Jesset, Medical Officer of Health for the Urban District of Erith.
Dr. Collingridge, Medical Officer of Health to the Port of London Sanitary Authority.
Dr. Corfield, Professor of Hygiene at University College.
And Dr. Browning, Medical Officer of Health for Rotherhithe.

On the respondents' side.

Dr. Maxwell, Medical Practitioner at Woolwich.
Mr. Coleman ,, ,,
Dr. Lett ,, ,,
Dr. Wise ,, at Crossness.
Dr. Dixon, Medical Officer of Health for Bermondsey.
Mr. F. M. Corner, Medical Officer of Health for Poplar.
Mr. Tatham, Medical Practitioner on the river.
Mr. Mason ,, at North Woolwich.
Dr. Rowarth, Medical Officer of the "Exmouth."
Dr. Tripe, President of the Society of Medical Officers of Health.
Surgeon Major Griffith, in medical charge of the magazine at Purfleet.
Dr. Dickson, Medical Inspector to Her Majesty's Customs.

Professor Corfield has put in some tables which he considers show that the death rate from zymotic diseases is higher in the immediate neighbourhood of the river, the foul condition of which he considers may have contributed to this result.

But his conclusions are called in question, and do not appear to be supported, while the testimony of the respondents' witnesses unanimously asserts that no such deterioration of health can be perceived.

95. We cannot see sufficient evidence to show that, hitherto, the sewage discharge has produced any serious injury to health, either among those who live in the vicinity of the river, or those who live partially or wholly on the water in the neighbourhood of the outfalls.

96. But there is abundant evidence of its having produced affections of a slighter kind, as the following extracts will show:

*Beadle*, 262.—I have had constant complaints from my men as to illness resulting from the smell. In hot weather I cannot stand it; it produces a headache and makes me feel sick. We have had more men laid up in the last three years than ever before. In hot weather the men can scarcely stand it.

*Egerton* (*Erith, Surveyor*), 979.—My family have suffered illness from the smells arising from the river. Several physicians advised me to take my family away from the river, which I have done, seven or eight years ago.

*Savery* (*Custom House Officer*), 1460.—Diarrhœa on board vessels which he supervised.

*Sibley*, 2116.—Five or six of us have had to knock off work, and we have felt very queer.

*Lee*, 2279.—Often have the headache, and am sick from it in summer. Does not agree with my wife and daughter.

*Harling*, 2547.—I am under the doctor's hands from it now. Every time I go into the dock I am forced to go to him.

*Clarke*, 2607.—Nasty faint sickness.

*Roberts*, 2845.—Very sick at times. Man suffered from diarrhœa.

*Mastin* (*Policeman*), 3099.—I have had to go out of the boat on account of the smell, and felt very sick; and had to vomit once or twice.

*Capt. Lynch*, 3306.—Have known men to be sick from the smell.

*Capt. Hussey*, 3511.—My family have suffered, they were taken ill in the summer time.

*Fuller*, 3668.—For two summers I was very poorly with sickness.

*Edmunds*, 3976.—Ill with loss of appetite and faintness.

*Saunders*, 4046.—Several men laid up.

*Jesset*, 4434. — I have had occasion to treat persons for illness caused by this matter. Could name several cases. In one case a new man on the Thames Police yacht had not been on board above a week before he was seized with most violent diarrhœa and sickness; when removed, he got well. Number of men working in the mud and at the ballast wharf have suffered in the same way. A fair number of cases. Ladies on a yacht were sick, and could not take their tea on account of the atrocious smell.

*Rev. J. McAlister* (*Vicar of St. Nicholas, Plumstead*), 4817.—At certain seasons when these foul odours came over the parish, I have noticed that the effect produced upon the health of the inhabitants is much the same as the effect that a hot wind would have on vegetable life if it were blown over vegetable life, under certain conditions, *i.e.*, the *vis vitæ* sinks directly; and you find that the inhabitants, as a rule, myself included, feel it. I am as healthy a man perhaps as you would find anywhere, but I feel it as others do; that the vitality is not so powerful in the animal system as it is at other times. That is more the case than it used to be.

*Capt. James* (*Harbour Master*), 5807.—I have frequently been made quite ill with the smell, going up and down, so that I have not been able to eat my dinner when I have got home.

*Dr. Collingridge*, 5914.—I have frequently, in hot weather, been very seriously inconvenienced indeed. I have had distinct nausea, and, in bad cases, actual vomiting. I frequently get diarrhœa when I have been on the water in hot weather, for any length of time. I can, undoubtedly, attribute these symptoms to the state of the river.

*Long*, 5936.—Men on board the "Conservator" felt sick.

*Turnidge*, 6096.—I have felt very sick indeed at times: on one occasion I was obliged to give over altogether; I was absent from work.

*Custance*, 12,465.—The river has given great headache and diarrhœa to him and other men.

97. The above evidence shows that the sewage discharge does occasionally produce inconvenience, temporary indisposition, and a low state of vitality, the cause of which ought not to remain if reasonable means can be found for its removal. This result, however, is limited to those who are either actually upon the river, or on its margin; for we have strong and trustworthy evidence that the smell is not perceived a short distance from the river.

The constant presence of a large mass of water, containing a vast quantity of crude sewage, constitutes a danger to public health, which demands attention, more especially as the evil must increase with the growth of population.

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## (B.)

### General Nuisance and Inconvenience from the Pollution of the River.

98. In a former part of this Report, we have described the wide ultimate distribution, both up and down the river, of the discharge from the main sewage outfalls.

But with reference to the probable nuisance, it will be well to direct attention to the circumstances of the actual discharge from the outfalls, and to what takes place in their more immediate neighbourhood.

99. The volume of sewage discharged each tide is enormous.

Taking, as before stated, the average volume of sewage proper over the 24 hours to be 16,000 cubic feet per minute, and supposing it to be discharged during three hours every tide, there will, for those three hours, flow out a stream of about 64,000 cubic feet per minute; so that a mass of about $11\frac{1}{2}$ millions of cubic feet of concentrated sewage will enter the river in the three hours.

The stream of sewage flows out at Crossness under the surface of the water in the river. At Barking it discharges at a higher level and part of the time not under water; but in both cases it immediately becomes appreciable, and continues (as is usual where one stream joins another) unmixed for a considerable distance. It is allowed on all hands that this sewage stream, so long as it retains its separate character, is very offensive in its immediate neighbourhood.

After a time, the sewage stream begins to mix with the water of the river, and the mixture becomes less offensive. The solid matter, to which, more than to the fluid, we attribute the origin, proximately or remotely, of the offensive smells, decomposes; the noxious gases which result are dissolved in the water, and when the water is stirred up, they escape into the air. This agitation is effected by the passage of steamers, and as the traffic is very great, the effect is kept up for a considerable distance from the outfalls both up and down the river. Within this range the water is in such a foul state as not to be usable, even for such purposes as washing ships' decks, &c.

After a further time, and a more extended travel of the sewage discharge, the mixture with the river water becomes more complete, and a change takes place, on which great stress is laid on by the Metropolitan Board. They assert that, by the dilution with the river water, and by the constant agitation due to the tidal oscillation and other motions, a process of natural purification by oxidation sets in, which, in time, deprives the discharged fluid of its offensive properties, and causes it to become more like the natural water in the river.

This is admitted by the complainants, the only question being, how soon the purification becomes effective, and whether, in the meantime, nuisance is caused.

The limits of distance, above and below the outfalls, where this purification becomes effective in preventing nuisance are very indeterminate, varying much, at different periods, according to the supply of water to the river, and the temperature.

We may, however, state that there has been no evidence to lead us to believe that any substantial nuisance attributable to the metropolitan sewage is complained of above Greenwich, or below Greenhithe.

In regard, however, to the part of the river lying *between* these limits, it is complained that the effects of the sewage discharge are distinctly appreciable. The Metropolitan Board admit that some nuisance exists, and must, under the present system always exist, in the immediate neighbourhood of the outfalls; whilst the complainants assert that, in hot and dry weather, this nuisance becomes very considerable, and extends some distance both up and down the river, the question being one of degree.

There is also a further cause of complaint, namely, the deposit, in the neighbourhood of the outfalls, of a certain kind of mud, which when exposed at low water on the banks, or brought up by the dipping into it of ships' anchors, chains, nets, &c., is exceedingly offensive, and betrays sewage origin.

100. It is now our duty to state the general nature of the evidence we have received on this part of the case; and as this is, we conceive, the turning point of our whole inquiry, we feel it necessary to go into the matter in some detail.

The evidence is of two kinds, *popular* and *scientific*.

*Popular Evidence.*

101. Before discussing this, it is right to mention the complaints made before this Commission was appointed.

The complaint from Barking in 1868, which we have already mentioned, alleged the pollution of the river, and the allegation was confirmed in Mr. Rawlinson's Report.

In October 1878, shortly after the lamentable loss of life by the sinking of the "Princess Alice" steamboat, near the Barking outfall, the Woolwich Local Board directed their surveyor to take samples of the water in the Thames, in and about the spot where the accident occurred, and to have them analysed. This proceeding had special reference to the question whether the water was so contaminated by sewage discharge as to cause the death of any of the passengers in the unfortunate vessel.

The reports of the surveyor and of the analyst are printed in Appendix O., and the latter contains the following passages:

I think the various facts afford the most conclusive ground on which to base an opinion that the whole of the river from Billingsgate to Jenningtree Point was, on the 14th of October last, greatly contaminated with sewage, and that, subject to certain irregularities which may be due to local circumstances in the river, this contamination increased as we passed down, and that on the whole the greatest contamination was found in the samples taken at the wreck and half-way between the two outfalls.

In Appendix N. we give copies of a series of documents transmitted to us by the Thames Conservancy Board. They consist of various complaints made to them during some years before the appointment of this Commission. We add a few extracts. The Harbour Masters say, at various times—

16th July 1880. The river water every day and night has been heavily charged with sewage; the odour, even as far as Blackwall, is worse than I have known it. The water last Monday at nearly half flood was so bad that I landed at the southern outfall to ascertain if the sluices were not open. The foreman assured me they were closed.

The nuisance still continues to be felt, and is spoken of on all sides.

25th July 1880. Since my last report, the water has become much worse, and it is now so heavily charged with sewage matter that it cannot be used for the decks, or even in the cisterns, and has become a public nuisance.

Throughout the whole of my district (from Greenwich to Greenhithe) the water has been foul, and from Erith upwards the water is crowded with sewage at all times of tide.

The stream between Halfway Reach and Woolwich is nearly black at half tide, both on the flood and ebb, and I have no hesitation in describing it as little better than an open sewer in this part of the river. At the top of high water sewage is present in all directions, which is quite a new feature in my experience.

It is my opinion that the present filthy state of the river calls for the immediate attention of the port sanitary authorities.

26th July. The river on the flood tide on the 24th inst. was in a very bad state, the water black and full of filthy black looking matter in suspension, and giving forth a most disagreeable smell. At Millwall it got worse, and off Port of London Wharf and as far as East Greenwich at three-quarter flood the odour was horrible and sickening. The effect was felt by all the crew of my boat.

5th July 1881. The water of the river is this day very offensive on the ebb, more particularly so at high water this morning.

14th July 1881. Water very dark, discoloured, and offensive this day towards high water.

20th July 1881. River during the past week in a very filthy state. Between Purfleet and Charlton more especially it is heavily charged with sewage matter visible at all times of the tide, and its sickly odour pervades every part of the district.

See also a long series of extracts from the Harbour Master's Journal (central station) extending from the 20th December 1878 to the 21st August 1881.

Captain Gillett, R.N., captain of the "Warspite," lying off Woolwich, writes, 27th July 1880—

I think it my duty to report the bad state of the river where this ship is lying. It is no exaggeration to say that for several days past the whole river has been neither more nor less than an open sewer, the water of a dark slate colour, and large masses of solid sewage floating past.

Mr. W. Woolcott of the Trinity House, says, 21st July 1881—

I beg to call your attention to the filthy state of the river between Blackwall and Tripcock Point. I slept on board the "Galatea" on Sunday night last, and was obliged to close the scuttle owing to the smell of the water passing the paddles. The water was quite black. Everybody I met was complaining bitterly about the state of the river.

The Secretary of the London Steamboat Company writes, 25th July 1881—

We have lately had so many complaints from our captains, as well as from passengers by our steamboats, that we now send you from our lessees a formal complaint setting forth the facts referred to in language unmistakeable.

The General Manager and Secretary of the Thames and Channel Steamship Company notes, on the same day—

The filthy state of the river below bridge, more particularly about Woolwich. The effluvia thrown off by the sewage floating up and down in the stream is positively poisonous, the river being for miles black with it. As an instance, yesterday morning at 10 o'clock the passengers on board the "Eclair," at Woolwich, were seriously annoyed; the smell was almost unbearable.

The Local Government Board transmit a Resolution dated 20th September 1881, received from the Vestry of Plumstead, stating that their attention had been further drawn to the alleged nuisance by an influential and representative deputation from the locality. The Resolution states—

That this Vestry expresses its abhorrence at the continued impurities from sewage existing in the Thames near the metropolis, contrary to the 135th section of the Metropolis Local Management Act, 1855; and that this resolution be forwarded to the Local Government Board with an earnest hope that it will concert measures to remedy the evil complained of.

The Conservancy Board give extracts from their own annual report for 1880, which contains the following passage:

During hot weather, when there has been little rainfall, complaints of the pollution of the river within and below the metropolitan district frequently reach the Conservators. The pollution thus complained of is indicated by the offensive odour and highly discoloured state of the water.

In Appendix A. J. we have printed some of the annual reports to the Erith Local Board, from their medical officer, Mr. Jessett. In the two dated 29th January 1879, and the 22nd January 1880, he alludes briefly to the deposit of sewage on the river banks near that town. In a subsequent one, dated January 25th, 1882, occur the following passages:

I was most pleased to see that your Board fully entered into the vital importance of endeavouring to force the Metropolitan Board to do something to abate the abominable nuisance they are causing by pumping the enormous amount of sewage into the river at Crossness and Barking.

There are few among you who do not remember the vile stench emitted from the mud on our shore at low tide during the excessive heat of last summer. Without exception I will venture to assert all the yachtsmen who lay off our town will agree as to the filthy masses of black sewage washed backwards and forwards by their yachts during that excessive heat, and of the stench emitted from the river generally. It was a source of some surprise to me that fever of the most virulent type was not manifest among the crews of the yachts.

In October 1881, the Common Council of the City of London instructed the Port Sanitary Committee to inquire into the sanitary condition of the River Thames in the neighbourhood of the outfalls. They reported on the 14th December of that year, and we give a copy of their report in Appendix P. The essence of it is as follows—

In the minds of your committee there can be no doubt that the action of the Metropolitan Board of Works in taking the sewage of the metropolis down the river to Crossness and Barking Creek, has materially benefited that part of the Thames immediately adjacent to London; but equally without doubt the state of the river at these points, although, being greatly affected by meteorological changes, it must of necessity vary from time to time, is, in consequence of the great outpouring of sewage, always in a condition most unsanitary, and that in hot weather, in times of drought and great heat, its very prejudicial effect upon the public health is obvious. And bearing in mind the fact that the quantity of sewage has of late years enormously increased, and is constantly increasing, your committee feel that the time has arrived when some definite action should be taken in the matter.

This opinion is confirmed in a subsequent report, dated 16th March 1882.

In March 1882 a number of gentlemen in the City, interested in the traffic on the Lower Thames, held a meeting, at which a resolution was passed—

That, in the opinion of this committee, a Royal Commission should be appointed, or a parliamentary inquiry instituted, for the investigation of the present state of pollution of the River Thames from sewage, and the means to be taken to remedy this alarming and growing evil.

An executive committee was formed, and in the month of April a memorial on the subject was presented to the Right Hon. W. E. Gladstone. A copy of this is printed in Appendix K. It was entitled—

*The* MEMORIAL *of the principal merchants, traders, and shipowners, and the representatives of the dock, wharf, and shipping interests on the River Thames, the owners of barges and the steam vessels engaged in the passenger traffic of that river, associated together, and forming a general committee for the protection of the Lower Thames from sewage.*

It recited a petition, signed by above 13,000 persons, of many different classes in life, that had been presented to Parliament in the previous session, and it contained the following statements:

That the Metropolis Local Management Act, 1858, which authorises the discharge of the metropolitan sewage at Barking and Crossness, was passed, as your memorialists are informed, under the belief, "First, "that the sewage discharged would not increase to the enormous extent it has done; secondly, that the sewage "would be deodorized before its discharge into the river; and thirdly, that the action of the tide in the river "would have the effect of carrying the sewage water or matter into the sea, instead of its remaining in the "river, as is now the case, and being carried up and down between Gravesend and Blackwall, or points higher "up the stream."

That, although the 23rd section of that Act (for deodorizing the sewage) may be construed as having application only to the period during which the works under the Act were in course of construction, the spirit and contention of the 24th section (forbidding any nuisance) is obviously to prevent the nuisance now complained of, although, according to the legal construction of the words of the said section, it does not supply the means of enforcing such intention.

The memorial prayed the appointment of a Royal Commission to inquire into the matter.

It was signed on behalf of the memorialists by Professor J. E. Thorold Rogers, M.P. for Southwark, and there was appended a list of the committee, 159 in number, among whom were many gentlemen and firms of high character and position.

Early in 1882 the town clerk of the corporation of the City of London wrote to the Home Secretary a letter,* as follows:—

SIR, Guildhall, E.C., 19th January 1882.

THE question of the pollution of the River Thames by sewage from the outfalls at Crossness and other places has recently been the subject of serious consideration by the Port of London Sanitary Committee of the Corporation; and, guided by personal inspection and the results of a careful chemical analysis of the water of the river in the localities in question, they find that without doubt the state of the river at Crossness and Barking Creek (although in consequence of constant meteorological changes it must of necessity vary from

* The correspondence here mentioned is printed in Appendix J.

time to time) is, from the great outpouring of sewage, always in a condition most unsanitary, exercising, in periods of drought and great heat, very prejudicial effects upon the public health; and, bearing in mind the fact that the quantity of sewage has of late years enormously increased and is constantly increasing, the Committee feel that the time has arrived when some decisive action should be taken in the matter, and they therefore deem it expedient to take the step which, under the Metropolis Local Management Act, 1858, cap. 104. sec. 31, is open for adoption, and I am therefore instructed to urge upon you the extreme importance of immediate steps being taken towards remedying that which must be admitted to be a great and growing evil.

I have, &c.

(Signed) JOHN B. MONCKTON.

About the same time applications of a similar character were made by the Woolwich Local Board.

The Local Board of Plumstead also applied to the Local Government Board, who transmitted the complaint on to the Home Office.

The complaints were referred to the Metropolitan Board, who denied the allegations made. The Home Secretary then, in a letter dated 25th May 1882, declared his intention of causing an inquiry to be made, and the result was the issue of your Majesty's Warrant appointing the present Commission.

102. We may now refer to the popular evidence, from direct observation, taken on our own inquiry.

Evidence of this kind has been given, on behalf of the complainants, by a very large number of witnesses, of different ranks in life.

103. First as to the *General Foul State of the Water*. The following are abbreviated extracts from the statements made, using generally the actual words of the witnesses.

The references are only to the earlier numbers of the questions. It will be easy to identify the succeeding portions.

*Beadle*, 236.—The river has been growing gradually more dirty and more objectionable. It is getting worse every year. In hot weather there is a very disagreeable smell, particularly in the last few years. Coming up the river, it begins to get thick in the Lower Hope, it gradually gets worse till you reach the outfalls, which is the worst place, then it begins to get better again till you get up to Greenwich, and before you come to London Bridge you come to very decent water again. The worst part is from Blackwall to Greenhithe. The water turns black and gives off a gas from bubbles with a disagreeable smell, a sewage smell. In hot weather I cannot stand it.

*Busby* (*Pilot*), 446.—These last four or five years, to come up on board of a ship with a tug towing ahead of you to stir the water up, is dreadful. From Erith to Woolwich is, I consider, the most obnoxious and the largest cesspool in the world. I often hold my handkerchief to my nose for an hour together. The men do not clean the decks as they used to do, on account of the water being so filthy and black as ink; the mate has knocked them off, and let them begin again in Long Reach. The obnoxious stuff, unless it is a very hot summer, has not come into Long Reach yet. The sewage water would come up as far as Greenwich, or even further. You would see just at high water a large circle from the outlet right over to the other side and extending a mile, black as ink. The Members of Parliament got it in 1859, and we get it now. If everything is still and quiet, it is something frightful on hot summer mornings.

*Sandford* (*Pilot*), 547.—Since the outfall was opened, it has gradually got so bad, and now it is as bad as the upper part was before. It has been gradually getting worse the last eight or nine years. We get worse water round Maggotness; the "Stink Factory" we call it in Jenningtree Reach. We used to make our best effort to watch the time, to get clear of the stench. We would lose an hour to clear it.

*Capt. Morrel, R.N.*, 660.—I consider the river near Erith very much impurer of recent years. I have discontinued washing the decks several years, because the water used to smell so badly that it was unhealthy; a sickening smell arising from gases.

*Capt. Walter, R.N.*, 731.—In my opinion the state of the river has been worse during the last eight years. There is a smell from the water in hot weather and at low tide.

*Capt. Gillet, R.N.*, 804.—For a month in the middle of the summer, generally in July, it has been very bad; the water becomes slate coloured, and great masses of black mud come up from the bottom and spread all over the surface. It has been very bad indeed. The smell is perfectly dreadful. I am obliged at night time to close all the ports and keep the deck under the hammocks wet with disinfectants. We do not use the water in summer for washing the upper deck or washing the boys. One of the mooring chains when lifted was all covered with sewage. When the river gets slate colour, which it does in the summer, the oars and the blades all turn black. The sewage comes up to Woolwich. The whole bed of the river, I believe, is covered with it 20 inches, and when the temperature rises to a certain point, it rises with it. It appears as if gases exploded in the bed of the river, because it comes up and spreads all over. It comes up in great masses of black stuff, sometimes as big as this room.

*Egerton* (*Surveyor, of Erith*), 913.—I have noticed a very great alteration in the state of the river since the outfalls were opened. I have noticed the water coming out of the outfalls at different times, and I could see and trace it down as far as Erith by the different colour. There is a very bad smell at times like a cesspool emptied two or three days. It is worse in warm weather about half ebb. I live upon the hill, and when I am half way down the hill, about from 70 to 80 feet above the level of the water, I get into the smell, and it seems as if I could not get out of it. You can get out of the factory smells, but out of the smell of the river you cannot get, and a very nauseous and unpleasant smell it is.

*Hind*, 1116.—I have found coming from the river a smell very much resembling a cesspool. Describes the offensive state of the bodies of persons drowned in the "Princess Alice."

*Cobb*, 1237.—Fishing nets are covered with all manner of filth. The water stinks enough to poison you.

*Savery* (*Customs Officer*), 1421.—On some occasions the state of the river has been very bad, particularly in warm weather. Last year, on two or three occasions it was unbearable on the water. It is worst in Halfway Reach.

*Farthing*, 1607.—Fourteen years ago the water was formerly taken by ships for drinking, now it would be poison. At high water in summer time it stinks awful, even up at Greenwich.

*Thorne*, 1744.—The same water is now very bad and black and stinking. It does not get up so far as Deptford. It comes about up to Bugsby's Hole and above.

*Parkinson* (*Pilot*), 1833.—The same; now it is rank poison.

*Brill*, 1966.—Water of a green greasy nature. Rots the nets. Plenty of lumps of sewage.

*Young*, 2034.—Rots nets. Boats' bottoms made much dirtier.

*Sibley*, 2090.—Very filthy. Very offensive smell, like a parcel of dead bodies floating about. Parties get their living by collecting grease.

*McKee*, 2203.—At high water, all dark fluid; floating masses of excrement and that sort of thing.

*Lee*, 2269.—Stuff from the human frame collects, stinking just like what it is. A lot worse than seven years ago. Slipway all slime, and during every low water always there, winter and summer. Dirties the boats. Increases.

*Hoskins*, 2347.—Filth, black; stench.

*Gatward* (*Constable*), 2646.—River very bad indeed after a hot day. Great quantity of refuse always left on the shore, smelling very bad, making you feel quite sick. Dead bodies from "Princess Alice" in a most beastly state; amongst the clothing there was a great quantity of slime and filth; when they had lain a few hours the smell nearly knocked you backwards when you went to them. Drowned bodies from other places looked fresher. Sometimes you cannot bear the smell as you go down the river; you are glad to run the boat ashore and get out of it. Seven men get their living by skimming the fat off the river. Lumps of filth floating about.

*Roberts* (*Police Inspector*), 2842.—The water has been very bad since the outfall was made. Bad smells emanating from it; most in close hot weather. Dead bodies from "Alice" in a very bad state after being a very short time in the water. Above Woolwich, water quite black. In the slack water, there is frequently lots of fat and slaughter-house refuse, and all manner of filth floating about.

*Carttar* (*Coroner*), 3014.—Bodies taken from the Thames are very much discoloured and disfigured. They turn various colours at various stages, and the decomposition is very rapid in summer, particularly in those that come from below Charlton; two or three days is sufficient. Often, deposits of mud and filth on the bodies; very offensive, and more so than with those bodies recovered from other waters with which I have to deal. A very marked difference. From Charlton down to Erith they come out worst. In a case on 16th July last, a body found after five days in Erith Wash was in a very bad state indeed, disfigured and swollen, and covered with filth and slime, and mud.

*Mastin* (*Policeman*), 3089.—Before outfalls were opened, there was not the foulness there is now. The water did not smell so bad. Dead bodies in a very decomposed state.

*Gilham* (*Police sergeant*), 3197.—River very bad indeed, thick and dirty. Smell very bad in hot weather. Bodies from "Princess Alice" were covered with slime and mud. The colour of their clothing was completely changed. They smelt very badly indeed. We had to boil the clothing before we could get it identified in many cases.

*Capt Lynch*, 3270.—Water dirty and thick before the Victoria entrance and Galleons entrance of Albert Docks. Closet filth floating.

*Showell* (*Inspector*), 3358.—Water in a filthy state; contains great amount of sewage. Worst smell in Woolwich Reach. Sewage matter floating. Coming up the river you would notice the change in the state of the water as you enter the Lower Hope, coming into Gravesend Reach.

*Rozier* (*Inspector*), 3466.—Water has been very bad in colour and stench since outfall opened.

*Capt. Hussey* (*Dock-master*), 3524.—Has seen the sewage eight miles above the outfall; it has got up now as far as Limehouse. Is of opinion it works its way higher up at the rate of about three-quarters of a mile a year.

*Shepherd* (*Tug captain*), 3898.—The river has been in a very bad state since the outfalls were opened. A lot of refuse swimming about with an odious smell; a stink of sewage. I should think it would not go further than the Lower Hope. Balls of sewage floating about.

*Edmunds* (*Barge builder*), 3969.—The lower reaches have become more foul year by year. A closet smell, but weaker, and more sickening.

*Marshall* (*Sexton of Erith*).—Bodies from "Princess Alice" were in a very dirty condition; clothing, one mass of filth; it looked like sewage; very horrible smell. Bodies from other parts of the Thames were not so.

*Naylor*, 4121.—The river has been in a much worse condition since the outfalls were opened; thick, muddy substance; smells intolerably. Dead bodies all in a filthy state.

*Showell* (*Inspector of Nuisances*), 4308.—Filth; sewage; great smell.

*Jesset* (*Medical Officer of Health*), 4430.—Thames, of late years, very bad. Bathing was formerly common; now it is impossible, by reason of the contaminated state of the river; increasing considerably. Last summer I saw large masses of sewage off Purfleet, as large as the table, floating about. Atrocious smell; have often noticed this.

*Armitage*, 4509.—Water very bad; very black indeed at certain times of the tide; bad stench.

*Brown*, 4592.—Water in a most filthy state; nothing but impure matter. Smell, enough to knock you down. Grease at the top, and underneath quite black.

*Martin*, 4687.—River in a filthy state as far down as Erith and Long Reach.

*Evans*, 4777.—Greasy stuff lies on the water.

*Rev. J. McAlister* (*Vicar of St. Nicholas, Plumstead*), 4795.—I have frequently seen sewage in the river, carried up by the tide.

*Lewis* (*Port Sanitary Inspector*), 5017.—There has been a most decided change in the character of the river between 1873 and the present time. In 1880 it was very black and very bad indeed during the summer, from Jenningtree Point up to Cherry Gardens Pier. Black patches; black stinking matter, which broke up at the slightest touch; patches many feet in length and breadth; stench fearful. Have traced sewage up to the lower part of Blackwall Reach. (*See* Note Book, Q. 5105.)

*Spadaccini* (*Port Sanitary Inspector*). (*See* Note Book, Q. 5276.)

*Capt. Marsden* (*Harbour Master*), 5356.—Smell in Halfway Reach most offensive and sickening. Stench and state of the river off Cubitt Town very bad. Black slimy appearance on the water. Very bad in Erith and Halfway reaches. River very much charged with sewage. Water very foul, and stinks from northern outfall to Erith.

*Showell*, 5423.—Have seen sewage at Woolwich and round the bight of East Greenwich.

*Capt. Fitzgerald, R.N.*, (*Thames harbour master*), 5487.—Change for the worse during the last five years; exceedingly bad in 1880. Quotes from note book, in which the following expressions occur:—"River water "most offensive; stream on flood and ebb apparently charged with sewage. Smell of sewage pervades the "river from Charlton to Erith quite as bad on the flood as on the ebb tide. Water strongly impregnated with "sewage. Very bad state off Charlton and Woolwich. Greatly discoloured with sewage in Bugsby and "Blackwall Reach. Water from Woolwich to Erith in a worse condition than I have ever known it; heavily "charged with sewage, and the stench almost unbearable. The Woolwich Reach almost black with sewage. "Immediately above Leather Bottle Point, the water was nearly black at the last quarter's flood, covering a "surface of nearly a mile. Sewage apparently washing its way higher up the river. River in a beastly state "again; one of the men sick. River choke full of sewage; landing places and foreshore full of it; stench "abominable. Patches of sewage all over the river; some six times as large as this room. River water "heavily charged with sewage; air bubbles visible right across the river." (Remarks more or less of the same nature are noted on 23 days in 1880, 16 days in 1881, and a few in 1882.)

*Capt. James* (*Harbour master*), 5743*a*.—Water in Halfway Reach was formerly drunk; it has now got very foul. (Quotes his journal: "Water very foul and offensive" many days in 1880 and 1881.)

*Dr. Collingridge* (*Medical Officer of Health to the Port of London Sanitary Authority*), 5855.—During the summer months, more particularly, the river water has been extremely bad. Whenever we have continued hot weather, more than two or three days successively, the water becomes darker in colour, and we get this very offensive smell, that, of course, being always worse in the neighbourhood of the outfalls; and I also notice there black patches of sewage. The condition is exaggerated and often brought on by agitation. The water may be pretty clear on the surface, but much worse underneath. I should describe the patches as very slightly diluted sewage. There is a very large amount of suspended matter, and the smell from it is horrible. Sometimes you come upon very large masses; you get matches, paper, and vegetable matter. The surface of the sewage stream has an oily appearance, which I attribute to the greasy matter in the sewage. I have traced the discolouration and floating fœcal matter up to Blackwall, and higher up.

(Refers to his reports, which are printed in the evidence, Q. 5931, &c. These Reports called attention in 1880, 1881, and 1882, to the unsanitary state of the river, which had attracted the attention, not only of the officers, but of the general public. Many complaints had been received and much anxiety was felt, lest, with the continuance of hot weather, severe consequences should ensue. Public opinion and public indignation had been aroused.

Suggestions were also thrown out as to whether, if the constant outpouring continued, the Thames would any longer be a proper or safe river for stationing the training ships.)

*Long*, 5946.—You could see lumps of stuff rise from the bed of the river, and then they would break open, and a fearful stench come from them, all black mud stuff.

*Young* (*Master of Conservancy Steamer*), 6133.—I have found very great changes indeed in the character of the water. It is now nothing but a mass of sewage. (Gives various extracts from log as to the dirty state of the water and its effects; could not wash down the vessel in consequence).

*Shand* (*Manager of London Steamboat Company*), 7055.—I have seen the sewage more particularly between Greenwich and Woolwich; at Woolwich it was very bad. The river was in a very filthy condition; the stench was something fearful, more particularly above the paddles of our boats moored from the pier. We have had continual complaints from passengers, from the captains, and the men; I looked upon it as a very serious matter on behalf of the company.

*Jones*, 7078.—I get my living by getting the fat off the river at Barking Creek. I collect it, and steam it and sell it.

*Capt. Webb*, 7113.—Change since outfalls opened. We get the stench further down. When we are running two boats together, the boat to windward stirs the stuff up from the bed of the river and causes a great stench to the boat to leeward. We have frequently complaints from passengers; if a boat happens to be passing us at the time, there is hardly a passenger on board but what is obliged to put his handkerchief up to his face to avoid the stench.

*Capt. Huntingford*, 7139.—I know Bull's Point abreast of the Arsenal to Woolwich Pier; the river is in a very bad condition. There is an eddy there.

*Martin* (*Pier Master, Woolwich*), 7172.—Water in the neighbourhood of the pier very different from what it was formerly; very black, much blacker; little balls of fat drive by.

*Custance*, 12,450. — Before the outfalls were opened the river at Erith was clear and wholesome and healthy; now it is very bad.

*Baldwin Latham*, 8005–9.—I have seen the river myself on one or two occasions when I have been down it this year, simply bubbling up from the effects of fermentation and black in colour. In the summer of 1878, when I was down the river, it was certainly most frightfully offensive, it was like sailing on the top of a cesspool, containing diluted cesspool matter. This was more or less so from Deptford to below Erith.

*C. J. More*, 9010.—I have noticed frequently in the summer time there is a most offensive smell in the reaches near the outfalls, from the water; there is no doubt about that. I have smelt it even at Woolwich in hot weather, when it has been stirred up by a steamboat, and there has been a horrible smell.

*R. W. P. Birch*, 9287–8.—The appearance of the surface of the river must be very striking to anybody who is constantly passing up and down; that is to say, the floating sewage. I have drifted up in a steamer amongst the sewage and seen the most undisguised sewage upon the surface up as high at Blackwall, and down the river certainly as low as Purfleet, pretty nearly every day. Standing on the sponsons of the tug, the spray from the water would come in your face, and you would be thus reminded of the sewage most distinctly. I have noticed that as far down as Erith on more than one occasion.

*Dr. Tidy*, 9925–9.—On 15 November 1879, he and Dr. Frankland saw a rapid stream of sewage, calculated at 20 to 30 million gallons [a day] flowing over the apron of the outfall at dead low water; owing to the steam given off it looked boiling hot, and the bubbling gases indicated the most active putrefaction; the smell was exceedingly foul. From that and other inspections, he is convinced that under certain conditions of water and of tide and so on, a very great nuisance undoubtedly exists.

*Dr. Frankland*, 10,686–701.—After the opening of the outfalls, the river markedly improved in purity; but since that time, from soon after the main drainage outfalls were opened, the purity of the river in London has been decreasing. As we went down the river, the water became more and more polluted. Corroborates Dr. Tidy's statement as to a very large discharge on one day of offensive sewage from the northern outfall at dead low water.

*Heaton* (*Lecturer on Chemistry at Charing Cross Hospital*) 11,335.—Disagreeable smells from the river in hot weather, miles away from the outfall.

*Professor Tuson* (*Lecturer on Chemistry*), 11,525.—The condition of the river is steadily getting worse and worse from year to year, from Woolwich Pier as far as Greenhithe. Has been getting worse for the last 10 years, judging from the appearance, the blackness of the river, its turbidity, and the stench arising from it. In Long Reach it is turbid, black, and sewagelike, with innumerable bubbles sluggishly rising and discharging gas, and in hot weather this is accompanied by a most fearful stench. There was bathing formerly at Erith, but there is none now. Corroborates Mr. Heaton's analyses.

*Professor Corfield, M.D.*, 11,759.—Found sewage flowing up stream from both outfalls; marked distinctly by the floating material, Stench very bad at both outfalls.

Sample taken off Woolwich was highly polluted (describes analyses of this and others).

Describes cases of illness due to immersion in the Thames at the time of the accident to the "Princess Alice."

104. The following popular evidence has reference more particularly to the deposit and accumulation of *foul mud* in the river:

*Beadle*, 264.—The mud deposit at Erith, is black disagreable mud, quite unlike what it used to be. There was a great deal of mud deposited in a vessel sunk; it had a great smell. The mud has grown up in Erith bay in the last 20 years, 10 to 12 feet. The river makes eddies there. The sewage collects there and deposits on the banks. The sun causes the matter to decompose and to give off a gas; that is what we suffer from most. The causeway has been lengthened 100 feet. They are now obliged to have a floating one. It has been growing up for the last 15 or 20 years, more particularly the last 10 years. A slimy black mud, much dirtier, and more offensive than ordinary Thames mud, and when the sun is out, much more offensive than any mud I know. It never was so bad as it is now. Each year now would double this evil. The worst point is from Jenningtree Point to Erith. It is silting up in Church Hole very fast indeed.

*Busby* (*Pilot*), 453.—I have had a vessel lying at Erith, and the place has been very nearly ankle deep on the shore with the slush which has come out of the sewer. Erith, you may say, is the essence of the jelly bag; they get it worst there.

*Sandford* (*Pilot*), 553.—The mud is accumulating fast under Crossness. There has been a greater deposit of mud on the south shore in the last five or six years. It is marvellous how it has grown up there.

*Mr. Harry Leach's Medical Report on the "Cornwall,"* 863.—It is important to notice that the adjacent foreshore (near Purfleet) is frequently covered with decomposing sewage, brought by a strong ebb tide from the Metropolitan drainage outfalls at Barking and Crossness.

*Egerton* (*Erith Surveyor*), 901.—The river has altered very much during the last 21 years. The water has receded. There is very much more mud about Church Hole than there used to be. When the sun is out very hot, and the wind is off the water, it smells very bad.

*Hind*, 1103.—The causeway has been lengthened and raised because the mud grew up so much around it, that it was entirely covered. The mud has been accumulating ever since the outfalls were opened. It is black stinking mud; at the end of the causeway there must be at least 10 or 11 feet perpendicular of solid mud or muck. The smell is altogether different from what it was when the sewer was opened.

*Cobb*, 1244.—There is something at the bottom of the river that smells worse than any closet. The same at Church Hole. It gets worse and worse every day. An anchor was lost in the mud. From Erith and a little below Erith, and up to the outfall, and a little below the outfall, we get that black dreadful sewage along the banks. I have recently on some occasions gone and lifted some with a scull, and it seemed to me to be pure black sewage. I found an enormous accumulation along the outfall right up that reach to the point at the top of Erith reach and right away down Erith Reach. On the south shore above Erith, there are very large deposits of mud, where the steam boats used to go in at certain times of the tide without difficulty, but now they stir up the sewage and they get in with great difficulty. There has been an increase during the last few years. The banks appear to be solid black sewage. At low water on a hot day, it smells dreadfully. The sewage lies by the Causeway in heaps and piles, and it is unquestionably accumulating; it is black and smelling. No deposit much below Erith, that is the great receptacle; there is no doubt to any one observing, as I have done daily, that the increase there is enormous, many feet deep all of the same character, not such as you would get from the banks of the Thames.

*Hathaway*, 1556.—Accumulation of mud at Erith Causeway; nasty black stinking stuff, you cannot call it mud, it is not mud.

*Farthing*, 1633–6.—If you let go an anchor, it is like hauling up so much grease, you would hardly make out whether the anchor was iron or a lump of muck. A mixture of mud and slime like grease, smelling beastly. All the way up and down along the south shore from the sewers, right down below Erith.

*Clarke*, 1692.—All a black slimy mud up to your middle.

*Thorne*, 1778.—It is not mud, it is more like slime; black, very black indeed.

*Parkinson*, 1829.—Before the outfalls were made, the shores were clean mud, now it is all sorts of colours; where it was sand, it is all muck. Where we had 15 and 16 feet of water in Halfway Reach, we have about 9 feet now. Muck on the anchor and chains; it is not mud, and it smells fit to choke you; you have a boat to sweep it off to prevent it coming on board; I think it gets worse and worse every year. Where barges used to get sand, it is now all muck.

*Brill*, 1940.—Shore all slushy muck, imitating a cesspool; smells very strong. Growing very fast lately all along Erith, if it washes away, it very soon appears again. It still increases.

*Young*, 2020.—Bottom nothing else but all filth. Anchor line three inches thick with muck and paper and all manner of filth; smells dreadful. Anchor would not hold, it is all of a "slather."

*Sibley*, 2098.—A very great deal of slush like night soil; increases wonderfully. Creek fills up with it. Nothing but sewage collects in Church Hole.

*Hoskins*, 2367.—Filth increases.

*Faulkner*, 2443.—Black mud smells like night soil, created on the shore at Erith; increases. Black like closet stuff. Stench in summer. Stuff from the closet comes down there whole, not washed to pieces. Increased 8 to 10 feet in the last 18 to 20 years.

*Harling*, 2537.—Filth all along the shore, greasified; like your own manure in great lumps all along the sides of the dock; dung; closet stuff, black stuff, not mud. Accumulates in the docks.

*Clarke*, 2609.—Black nasty filth, like stuff from the human body. It creates more, and gets worse.

*Gatward* (*Constable*), 2650.—Greasy slimy stuff. Mud and slime stuff, and stuff on causeway with very great smell. Mud along the foreshore like filth.

*Roberts* (*Police Constable*), 2859.—Mud terribly black and dirty, and smells very badly when washed up by steamers. Accumulated until recently, but now drawing off.

*Mastin* (*Policeman*), 3098.—The mud has a very offensive smell.

*Gilham* (*Police Sergeant*), 3222.—The causeway at Woolwich has to be washed down as the tide recedes. It is very slimy and slippery, and covered with filth, generally black mud. Bad, smelling in hot weather.

*Capt. Lynch* (*Dockmaster, Albert Docks*, 3275).—The mud in the Albert Docks has accumulated very fast in the last two years. Blacker in appearance. Smells very much.

*Showell*, 3363.—Mud in a very bad state. Dreadful stink.

*Rozier*, 3476.—Mud quite black. Offensive smell in summer.

*Capt. Hussey* (*Dockmaster*), 3503.—There has been an enormous difference in the accumulation of the mud at the entrance of the East and West India Docks in the last three or four years, and especially this year. At first there was a decrease after the outfalls were opened, since then it has been gradually increasing, working its way up. In 1879, 60,000 tons cleared the whole, this year it is estimated at 160,000 tons. A large proportion of it is sewage. The stench from it is something awful in the summer time.

*Fuller* (*Dredging Contractor*), 3611.—Used to dredge clear building sand at Jenningtree Point and elsewhere; but since the outfalls have been opened they have been driven lower down, and have now to go to Coalhouse Point, below Gravesend. Ceased to dredge at Jenningtree Point after the sewer was opened. Customers complained of the filth in the sand. The Gravesend sand is spoilt now, being covered with filth to a depth of 18 inches. Our frontage of 1,000 feet at Woolwich is in a dreadful state, covered with about 18 inches of this filthy stuff. In summer it smells awful. I call it sewage. Barges sunk get a bad sediment of mud and sewage.

*Williams* (*Dredger Captain*), 3718.—Have found a great deal of soil in Long Reach. Sometimes the gravel is dirty; quite sewage.

*Whitehorn* (*Dredger Captain*), 3791.—Left Erith Reach on account of the badness of the stuff. With a bucket of gravel we should have a quantity of sewage matter.

*Capt. Shepherd*, 3917.—The mud on the banks is black and greasy, with a very bad smell like sewage.

*Edmunds*, 3982.—Thick mud and very stinking.

*Saunders*, 4036.—Great accumulation of sewage stuff in the berths when the ships come, and we have great difficulty in keeping them clean. Nasty sort of smell. Barge sunk was in a fearful state when raised, with a kind of sewage mud.

*Showell* (*Inspector of Nuisances*), 4318.—Mud more like filth and such like along the shores. Sewage settles down in Halfway Reach and about Erith. Deposits 8 or 10 feet deep.

*Evans*, 4409.—Grapplings are choked with so much filth, slime, and stinking mud. Can hardly bear the stench in the summer.

*Jesset* (*Medical Officer*), 4464.—You see the gases bubbling up through the mud at low tide constantly.

*Armitage*, 4511.—The settlements along the shore are quite black and slimy. At Long Reach very bad indeed. Solid banks of mud seven or eight feet high.

*Brown*, 4592.—My cable and anchor when I heave it up are blacker than my clothes. Nothing but stinking filthy matter.

*Martin*, 4687.—River fills up very much with mud and slush and muck. Stinks filthy.

*Tall*, 4736.—Dirty filthy black mud. Stinks very much. Increasing fast.

*Evans* (*Dredger*), 4772.—At Jenningtree Point formerly the sand was always very good and clear, but of late years it has been very filthy and dark. In warm weather we could scarcely stand to our tools to work it for the stench and the refuse under the sand.

*Rev. J. McAlister* (*Vicar of St. Nicholas, Plumstead*), 4802.—I have frequently and carefully examined the deposits on the sides of the banks. It was evidently human excrement in a state of decomposition, breeding living creatures, and having a very offensive smell, particularly in summer. All over the parish, a distance of three or four miles from the river, it is very offensive indeed. Very strong.

*Lewis* (*Port Sanitary Inspector*), 5119.—There is a mud bank near upper outfall which stinks very much. I cannot describe it. It is fearful. The boatman happened to put his oar in there. I had a man and a boy in the boat, and it knocked the boy up. He was ill for a day or two. It was really shocking.

*Capt. Fitzgerald* (*Harbour Master*), 5542.—Foreshore and some of the landing places are clothed with sewage mud. Mud increasing in the river in some places, black and stinking.

*Dr. Collingridge*, 5918.—The mud deposited on the banks, particularly nearer to the outfalls, is dark, slimy, black stuff, and has a peculiar gelatinous appearance.

*Hughes* (*Solicitor to Woolwich Local Board*), 6687.—There is an increase of the filth on the banks of the river since the opening of the outfall. It used to be a natural mud, now it is an artificial mud. You cannot land from a boat now in many places where you used to be able to land, but you now come against a mud bank, and if you got out, you would be suffocated. The colour of this deposit has entirely changed since the opening of the outfall. It is as black as ink.

*Martin* (*Pier Master, Woolwich*), 7184.—We have sometimes two or three steamers at a time, and then they stir the mud up; and it is a sort of blue black colour; and the stench is something horrible then. It is simply awful.

*Wood*, 12,384.—Near Dagenham in 1861 the ground was perfectly clear, a hard shingle; in 1882 there was nine feet of mud on the same spot, black mud, all sewage. Barges lately raised at Northfleet Hope had a great quantity of mud in them; it smells and is very black. The mud is all sorts, sponges, and rags, and guts, and all sorts of things.

*Capt. Burstal, R.N.* (*Secretary to the Thames Conservancy*), 6391, &c.—Mud banks have been deposited since 1861. The bank on the north side of Barking Reach is composed of very black mud, very deep, and very slimy, with not much sand or gravel in it; not at all like ordinary river mud. In warm weather it smells very badly. This applies also to the mud in Erith Reach and other banks in the neighbourhood. There is slack water in some places. There had been no accumulation on the south shore at Erith before 1861; now a very large accumulation has taken place all the way along the shore, to the depth of 7 to 10 feet vertically. It extends three-quarters of a mile. There is still an accumulation going on. The causeway has been lengthened 150 feet. He produces sections of the river at Erith, showing the accumulations.

*Mansergh*, 8730. — By plotting areas in Half-way Reach we have found a constriction in the river; the deposition of the mud has made the river too small for its work, showing that there is some exceptional cause at work to keep the river small. Either the stuff itself cannot be removed by the currents, or, if it is removed, it is immediately replaced. This mud is caused by a deposition of the ordinary suspended matter of the river *plus* the ordinary suspended matter of the sewers; and anything that points to such an accumulation of dirty mud is to the point in this case.

There is some abnormal cause which allows the river to remain constricted at that point. (*See also* 9065 to 75.)

*More*, 8967.—Finds accumulations of mud in many parts of the bed of the Thames. It is found, in parts, almost entirely across the bed; at other parts it is simply in bights. (*Puts in plans which show this.*)

The mud is of all depths, from 6 or 7 inches to 8 or 10 feet deep. It is evident that it has been brought there, because the natural bed of the river was gravel originally.

There is not much in Bugsby's Reach, except on the foreshore. Woolwich Reach is a very muddy reach indeed; there is a very large deposit of mud there, extending almost across the reach, the depth varying year by year. Galleons Reach, upon the Essex side, is very muddy indeed, all along the bight. Near the Beckton Gasworks there is a great depth of mud, which extends as far as Barking Creek all round the lower end of the bight; this is 6 or 8 feet deep. Barking Reach is very muddy from Margaretness on the north side to Crossness on the south side, and from False Point as far as opposite Dagenham on the north side. It extends very nearly across at one point. Half-way Reach is extremely muddy, especially all along the south side where the southern outfalls are—this is 9 or 10 feet depth far out into the river, and that mud is gradually extending down to the lower end of the reach, and further out into the centre of the river. There is also mud off the north side, opposite Jenningtree Point. In Erith Reach from Jenningtree Point down to Erith, all down the Kentish side of the river, is muddy; there is a great quantity of mud and of great depth towards the lower end of the reach. Off the town of Erith there is a very great deposit, 6 or 7 feet deep, going about one-third of the way across there. This has rather increased lately. The latest soundings show rather more mud than before at Crayfordness. You find mud in the centre of the river.

Between high and low water marks there is a great deal of mud all the way down past Gravesend. Knows places which he can remember quite clear, or, at all events, so that you could land from a boat without difficulty, where you have now 3 or 4 feet of mud.

The mud extends in area year by year. It has increased mostly in the neighbourhood of the outfalls in Barking and Halfway Reaches.

It is a very black, slimy sort of mud. It is blacker and of a more offensive character near the outfalls than elsewhere in the reaches; its offensive character is very much complained of by the men who are engaged by the Conservators to raise anchors and so on.

Puts in sections of the river near Erith. They show a very large accumulation of mud in 1882 since 1861 on the south side.

The flow of the stream is very variable indeed in the crooked parts of the river above Long Reach; there are eddies round the points.

Puts in area of cross sections of river at Erith, showing increase and decrease.

*Dr. Frankland*, 10,835–40.—Is of opinion that the river is rapidly becoming worse from the accumulation of mud banks which are increasing from year to year; these putrify in warm weather, and create a permanent nuisance. Thinks even if the amount of sewage thrown in does not increase, it will become worse, as the mud banks will go on increasing.

*Heaton*, 11,336.—Disagreeable smells from the mud.

*Tuson*, 11,534.—A quantity of stuff collects on the bottom of the boats; a blackish kind of mud, and when it is scraped off the stench from it is very bad, like the smell of fæcal matter decomposing.

*Dr. Browning* (*Medical Officer of Health for Rotherhithe*), 12,078–81.—Has taken specimens of mud near the outfalls, and at Wapping and Rotherhithe. It was very black and very fœtid, and showed evidence of sewage.

105. We have been informed by the complainants that this great mass of evidence is by no means the whole they are prepared to bring forward. They have tendered to us 282 more witnesses to the same facts; their names and heads of evidence being given in Appendix C.C. They comprise—

24 yacht owners.
55 captains of barges, &c.
85 free watermen and pilots.
61 fishermen.
57 general witnesses.

The reason we did not require the attendance of these witnesses was that it was admitted they were trustworthy persons, meaning to tell the truth, and that they would repeat the same evidence and opinions as had been previously given by others. Consequently their attendance would only have led to an unnecessary expenditure of time and money.

106. The popular evidence, from direct observation, offered by the respondents in answer to the above, has been as follows:

*Chatterton*, 12,970.—During a long time he was engaged in Long Reach, there was no perceptible smell of any kind, but there was an indication of the sewage. By watching the river very closely on a very calm day, you could notice cork and bits of vegetable, and traces of grease, &c., which would float upon the surface, but there was no possible means of detecting any large bulk of sewage by the nose or the eye.

In June and July 1877 never heard of any complaint; never noticed any offensiveness, and does not think it possible for anybody to have told whether there was sewage being discharged at the outfalls or not. His men used to bathe in the river in hot weather. He does not agree that the river would become noxious at about 65°. Many days that it was above that he never heard of a complaint.

Was 59 days in 1882 on the river making observations and taking samples. Followed the sewage down from the outfall. Near the outfalls it was very offensive. At less than half a mile down the traces were visible, but there was no smell in the air, although the water smelt when shaken violently. At 1¼ mile the water smelt faintly when shaken. At two miles below Crossness there was no smell. At Purfleet all traces were lost.

There was no smell in the Thames last year, unless you went into the immediate neighbourhood of the outfalls; the bad smells were from the factories on the shore, the Beckton Gas outfall, the Bow Creek sewage from West Ham, and so on. Much sewage is discharged into the river independently of the main outfalls.

There are great local nuisances from the Erith outfalls, and from factories on both sides of the river.

*Coleman*, 13,485.—The bodies from the Princess Alice had no particular appearance of sewage. Has been surprised how little smell there was stirred up by the paddle-wheels at Woolwich Ferry at low water. The smell from the factories is frightful at times.

*Law*, 13,972–3.—No person passing up and down the river, if they were not told that the sewage was discharged into it, would ever find it out, unless they were to row within, perhaps, a distance of 100 yards of the outfall. Compared with the offensive stenches from other sources, the nuisance of the sewage is inappreciable.

*Easton*, 15,207, &c.—The sites of the outfalls were well chosen; no more suitable positions could possibly have been found. Refers to his reports on the bad drainage of Erith, and the local nuisance arising therefrom. He recommended a proper system of sewerage, with deodorizing works. Off Crayfordness, when the sewage was discharging, there was no smell of sewage, or anything else in it. The chemical works are very offensive.

*Tatham*, 15,431, &c.—Has not heard any complaints for the last two or three years of the bad state of the river; two or three years ago they used to complain sometimes. In the hot weather he has noticed a little bad smell towards Blackwall. The water in the river is much clearer now than it was two or three years ago.

*Dr. Dickson*, 15,537.—Occasionally in hot weather there has been an unpleasant smell where the mud has been stirred up by the steamers, but not lately.

*Dibdin*, 15,701.—The Erith sewage is far fouler than anything obtained from the Board's sewers, and is a great deal more than sufficient to account for the complaints from the Erith people. Although the temperature of the Thames has been sometimes nearly up to 70 degrees, yet the odour was nothing more than you would find either down at Southend or up at Teddington. The factories are very offensive.

*Dr. Dupré*, 16,106.—He was 17 days on the river in the summer during July, August, and September; he could not on those occasions perceive any offensive or disagreeable smell from the water, except in the immediate neighbourhood of the outfalls. Has frequently examined the water at the spot where the "Princess Alice" went down, and never found it offensive. The actual stream of the sewage in hot weather is very offensive and very nauseating, but it is not a very powerful or penetrating smell, so that it is very soon lost; even if you go down in the actual sewage stream in ordinary weather, you lose the smell in about 1,000 yards; at 2,000 yards you see the stream by the floating matter—small pieces of cork and vegetable matter, and even small pieces of excrement, but it does not smell. Within a few hundred yards the sewage very rapidly mixes with the general body of the river. There are very bad smells from the factories and other sources.

*Sir F. Abel*, 16,261.—He has inspected the river several times in 1878, 1880, 1881, and 1882, and except when actually in the sewage flow, has only on one occasion at a distance from the sewage been able to recognise the distinct unmistakeable odour of sewage, and in that particular case there was a pretty steady and strong wind blowing towards him from the outfalls; this was between 1,000 and 1,200 yards from the outfalls. After 50 to 100 yards it becomes comparatively feeble, except when the water is stirred up by steamers. Has lived for 28 years at Woolwich Arsenal, within 180 to 250 yards of the river, and has not experienced any annoyance from it.

*Dr. Voelcker*, 16,366.—Bad local nuisances from Erith, sufficient to account for the complaints. No bad smells from the river except direct in the sewage stream, and this disappears at a distance of 600 to 700 yards. Bad smells from the factories. That there is a local nuisance cannot be denied; you cannot discharge a large body of sewage without it, but it is remarkable how quickly it is destroyed. He would limit the nuisance to 1,000 yards, or less.

*Dr. Odling*, 16,491.—The river, as a body of water, does not smell offensive or look offensive. There is no evidence to the senses that it is polluted; in warm weather the smell given off by the discharge of the sewage stream is sometimes offensive and nauseating; but it does not spread very far—not anything like a mile from the bank. The sewage could scarcely ever reach Woolwich in an offensive state, if it is discharged upon the turn of the tide.

*Dr. Sorby*, 16,592.—Lived in a yacht for some months in the warm part of the year near Erith and Greenhithe; and not one of his crew had the slightest fault to find with the river.

*Mason*, 16,833.—Has not noticed any smell from the river at Barking or East Ham; in the water at Barking at high water he has never noticed any indication of the presence of sewage. Saw a number of the bodies brought ashore from the "Princess Alice," did not observe anything unusual about them; saw no indication of sewage poisoning.

107. As to the allegations in respect to the *foul mud*, the respondents' witnesses testify as follows:

*Chatterton*, 12,971.—Became practically acquainted with the mud, some six or seven miles below the outfall, and never found it differed from ordinary Thames mud, or more disgusting in smell, or in any other way than any other mud. Does not think it possible, as far as the eye or the nose is concerned, to detect any change in the mud or the foreshore since 1877. The set of the tide has altered through the dredging.

As far as an ordinary person can detect there is no difference between the mud in Erith Bight and the mud at the mouth of all the creeks down the river.

Erith being in a bight the sewage never passes into it; it is deflected to the Essex side. Has never seen a float go into Erith bight at that time of the tide. The sewage cannot get there on an ebb tide.

*Law*, 13,880.—The Thames must be a muddy river. The mud washed from the banks contains nearly as much polluting matter as the mud from the sewage. Much detritus is brought down from above.

The mud of the river was in a bad state, and gave off poisonous gases in 1839, before sewage was turned into it. At the time of the Mud Inquiry the mud was found perfectly inoffensive, and no difference could be detected in any part of the river.

*Easton*, 15,224.—No more accumulation of mud at Erith now than there always has been. There is no gradual increase. Sand being dredged at Crayfordness was bright sand, used for building purposes. There was no offensive smell from the mud at Erith. Cannot see how the sewage from the metropolitan outfalls could be deposited on Erith bight. The deposit of animal matter at Erith practically arises from the Erith drainage.

*Dibdin*, 15,754.—There is no practical difference whatever in the composition of the mud from the various banks in the neighbourhood of the outfalls, between 1879 and 1883. A pure river in Queensland contains organic matter to nearly the same extent as the Thames.

*Dr. Dupré*, 15,966.—The Thames generally is muddy. The composition of the suspended matter in different parts of the river is very much alike, but sometimes it is worse at Teddington than at Crossness. All along the river from Teddington downwards the mud is very much the same; if there is a difference, that of the upper part of the river is slightly fouler than that of lower portion; almost the worst bank in the whole river is at Westminster. The bank at Erith does not differ in any way from the banks in other parts of the river.

*Sir F. Abel*, 16,231.—All muds which contain vegetable matter become putrescent, and emit an unpleasant smell. The black appearance of the mud, which gave to the uneducated mind a notion of filth and impurity, is really due to a purifying action. He visited the causeway at Erith in June and July; although he carefully searched for smell in the mud itself, he was unable to detect any.

*Sorby*, 16,642, &c.—In the mud banks complained of at Erith he finds exactly the same sand as is found in the old saltings, and considerably differing from the sand in the sewage.

The mud deposited at Erith differs from pure normal river mud by containing only a very small per-centage of material derived from the sewers, and less than one per cent. of that of objectionable character.

108. Members of the Commission on four occasions went on the river from above the outfalls through the sewage while discharging, and did not experience a sensible nuisance, except near the outfalls. On those days the weather was cool, there was a breeze blowing, with much fresh water, and on one occasion with a high spring tide. These were not days of such a character as those in regard to which the chief complaints were made; and the seasons were such that we were unable to find days convenient for our observation, when the combination of circumstances occurred, which have been described as causing or developing the nuisance.

*Scientific Evidence.*

109. In addition to the popular testimony as to the alleged nuisances from the sewage discharge, we have received a large amount of evidence on the same point, but of a different character, namely, evidence in which inferences are drawn by scientific reasoning.

A number of scientific witnesses, of high standing, have appeared before us, and an enormous mass of documents of various kinds has been put in, illustrative of the statements they have made.

We do not think it necessary to give any complete analysis of this evidence: there is much conflict of opinion as to the interpretation of the facts observed, and many of the points touched upon are confessedly obscure. And, on the whole, we are not inclined to attach so much weight to considerations of this speculative character, as to well substantiated statements derived from actual observation.

Moreover, while accepting in the main the facts presented to us, we have often found it difficult to determine their relevancy to the matters under inquiry.

All we propose to do therefore is to give a very brief indication of the general nature of the evidence in question.

110. On both sides, we have had engineers, chemists, and microscopists, all gentlemen of high professional standing.

On the part of the complainants:

*Mr. Baldwin Latham, Civil Engineer*, gives data and calculations as to the influence of temperature on the offensiveness of the discharge.

He further gives statements as to the quantity of solids in the sewage, and the probability of their deposit.

*Mr. Mansergh, Civil Engineer*, explains why, on engineering grounds, he considers the nuisances probable, particularly as regards the deposit of foul mud.

*Dr. Tidy* gives elaborate analyses of the water at different points of the river, which are referred to as showing the deterioration it suffered by the admixture of the sewage.

He also gives theoretical estimates of the quantities of offensive solids discharged into the rivers, and analyses of muds, to show their sewage origin.

*Dr. Frankland* has also made extensive independent analyses of other portions of the river, and gives copious statements of inferences from them, as also from the analyses of Dr. Tidy. He further gives elaborate calculations of the solid matters discharged.

*Mr. Heaton and Professor Tuson* give analyses having a similar tendency.

*Professor Way* gives statements and calculations showing the nuisances to be probable.

*Dr. Lionel Beale* describes a microscopical analysis of mud, showing it contains matter of sewage origin.

The respondents' scientific witnesses on this point are as follows:

*Mr. Law* asserts the large dilution of the sewage, which renders it innocuous.

He explains that the river is rendered naturally muddy by the washing away of the banks, &c., and states that the mud complained of is only the ordinary mud of the river.

*Mr. Dibdin, Dr. Dupré, Sir F. Abel, Dr. Odling, and Dr. Voelcker*, all testify to the efficiency of the purification effected by the oxidizing action; and assert that the purifying power is in excess of the present polluting influences.

*Dr. Sorby* adds that a large part of the more objectionable constituents of the sewage is removed in summer by the unobjectionable action of minute animals.

*Dr. Odling* asserts there is no definite body of polluted water which can be distinguished from the general mass of river water.

Several witnesses contest the statements made on the other side as to the solid contents of sewage.

111. On the whole the chemical analyses show that there is a progressively increasing impurity of the river from Teddington downwards to the outfalls; and then a decreasing impurity down to Gravesend, below which place the sewage is not perceptible. The oxygen dissolved in the water exhibits a corresponding decrease where the impurity increases, and *vice versâ*.

This shows not only the impurity of the water at and near the outfalls, but also that the oxygen does active work in oxidizing and thus purifying the sewage impurities in the river.

Besides the purification of the river by oxidation, there is evidence of its purification by means of animal and vegetable life. Animals of a low type, notably *entomostraca*, (such as water fleas) feed upon the solid elements of sewage. These animals themselves excrete solid matters, but of course in a diminished amount; the balance is decidedly in favour of purification.

Minute algæ and other plants of low organization vegetate in the polluted reaches, and, by giving off oxygen, they tend to promote the purification of the water.

The nett result of these complex processes:—pollution by sewage, oxidation of the sewage, consumption by minute animals, and re-oxygenation of the river by the action of vegetable life, and by renewed absorption of oxygen from the air, is, that in cold weather and in cool wet summers the pollution of the river water exists indeed, but does not increase; the above processes being adequate to prevent that. But during hot dry weather the pollution increases, exceeding the purifying power of the agents for its removal; and the river then becomes a nuisance, more or less great, and within greater or less limits.

*Remarks.*

112. Reviewing now the whole of this important part of the case, we find the real question to be, Is there a nuisance? and if so, to what extent? This seems to us substantially a question of fact; the scientific evidence, on either side, only tending to show that such a nuisance may or may not be expected.

We find it impossible not to be satisfied, by the overwhelming amount of concurrent evidence, much of it from indisputable sources, as to the real existence, under certain conditions, of the nuisances complained of.

It is altogether incredible that such a wide-spread feeling of dissatisfaction should prevail without reasonable ground, or can be the result of mistake. There is no reason to believe in any general hostility to the Metropolitan Board, and it seems impossible to account for the agitation, except for the justifiable motive of obtaining the removal of grievances which are felt to be serious and substantial.

113. The answer of the respondents to this evidence, so far as it can be inferred from the cross-examination, from their own evidence, and from the addresses of their counsel, appears to embody the following points.

*That the offensiveness of the sewage discharge is removed by natural purification in the river.*

We believe this has been fully substantiated, to the extent, at least, that no nuisance is proved beyond certain varying limits, above and below the outfalls. But it is between these limits where the offensiveness under certain circumstances exists, and it is to this space and to these circumstances that the complaints apply.

*That rebutting evidence has been given of the non-existence of the nuisances.*

It is true that several witnesses of high character have stated they have not experienced them, but as the nuisances only occur at certain times this is not inconsistent with the complainants' testimony, and cannot outweigh the immense accumulation of evidence to a contrary effect. Besides, it is admitted by many of the Board's witnesses that nuisance does occur within a certain distance of the outfalls.

*That the complaints have been much exaggerated.*

No doubt some of the statements are very strong, but even supposing that they may have been in some cases highly coloured, the fact only shows that a strong feeling

must have been aroused by the real existence of the evil. We may, however, make a very ample allowance, and still find sufficient remaining to substantiate the case; and we believe that we are making such an allowance when we limit the extent of the evil as we have done. The existence of the offensive smell and other matters complained of is a nuisance which ought not to occur if it is preventible.

*That the offensive smells complained of are due to chemical works and manufactories of various kinds in the neighbourhood of the outfalls.*

The existence of large numbers of these works, some of them giving off offensive effluvia, has been fully proved; but although the witnesses have been much pressed on the point in cross-examination, we believe it has been established that the sewage nuisance is sufficiently distinguishable from the factory smells. Our own experience, in the personal inspections we have made, confirms this view.

*That the nuisances are further due to local sewage from Erith, North Woolwich, Beckton, West Ham, and Barking, from the floating population, and other sources, not within the control of the Metropolitan Board, and also from manure and other offensive matters carried in barges on the river.*

The existence of some such nuisances has been shown: but it seems strange reasoning to refer the complaints to these comparatively insignificant sources, when a cause of immensely greater magnitude, of the same nature, is close at hand. And it is impossible to believe that the vast numbers of witnesses can universally have been deceived into attributing to the London sewage evils arising from the local causes mentioned in this and the preceding heads.

*That the complaints result from an agitation got up for the purpose.*

This appears solely to be founded on the fact that a meeting was held at a public-house, at which a certain number of the lower class of witnesses attended, and where the depositions were taken. But the objection has no value whatever, as it has never been alleged that there are any parties interested in getting up such an agitation, except for the legitimate purpose openly avowed. We have entire confidence in the good faith of the complainants and their witnesses.

*That, in regard to the complaints of the foul mud, the Thames is naturally muddy, the mud in it is generally offensive, and the deposits complained of do not differ in their composition from those in other parts of the river.*

To adopt this view would be simply to ignore the evidence on this point, or else to assume that the witnesses must be ignorant and incapable of judging of the matter they testify to, which we cannot believe.

*It is further said, that the positions of the outfalls are justifiable because of the many sources of nuisance in the immediate neighbourhood of them.*

We cannot consider this argument sound. The local nuisances have been much complained of, and they can be dealt with by law if they become intolerable. In any case, it seems to us a perversion of reasoning that their tolerance should be pleaded as a justification for adding to them.

We do not consider that by any of these objections, the immense amount of positive testimony to matters of actual fact has been invalidated.

114. And when we reflect on the magnitude of the causes in action, it is hardly surprising that some such effects as those complained of should occur.

In the first place, the daily quantity of sewage discharge is, as we have said, enormous. The flow of sewage proper is estimated at an average of 16,000 cubic feet per minute, which is 23,000,000 cubic feet per diem. Now the river at low water in the neighbourhood of the outfalls is about 2,000 feet broad, and has a sectional area of about 30,000 square feet, so that there is discharged into it every day as much undiluted sewage as would fill a length of 750 feet of this part of the river at low water.

Then if we estimate the quantity of foul matter which this discharge must of necessity contain, we arrive at quantities equally astounding. The quantity of fæces alone, in their natural state, passing from 3,800,000 people, has been stated at something like 400 tons a day; but if we consider also the urine, and the foul matter from other sources, and of other kinds, the total quantity must be very much larger.

The idea that these large quantities are unimportant in comparison with the

magnitude of the river into which they are discharged is, as we have already shown (paragraphs 87, 88), incorrect.

It would be difficult to suppose that such enormous amounts of polluting material could be destroyed by purifying action in so short a time as would be necessary to free the river from nuisance in the neighbourhood of their discharge. It is surprising that the nuisance is so far mitigated as we find it to be.

115. We do not find any reason to believe that the offensive exhalations are perceptible in such a degree as to cause nuisance to any great distance inland from the banks of the river. There has been some evidence to this effect, but it is not strong enough to satisfy us, and it is more probable that the offensive smells that penetrate inland are due to the factories. We consider that whatever nuisance there is affects only persons who are either on the river or on its immediate margin.

There is evidence to show that the suspended solid matters in the sewage are to a greater extent the origin of the offensive smells than the dissolved solid constituents of sewage.

---

## (C.)

### Injury to Fish.

116. Another of the complaints made of the effects of the sewage discharge is that of injury to fish, in the part of the river near the outfalls.

The testimony of all the witnesses on behalf of the complainants, in regard to this, is the same, namely, to the effect that, whereas formerly fish were caught in the neighbourhood of Woolwich, Erith, and so on, since the main outfalls have been opened the fish have been driven down to a much lower point, *i.e.*, to Gravesend or below. It is now, at times, impossible even to bring them alive through the water of the river above Gravesend.

It will only, therefore, be necessary to refer to the witnesses' statements, without quoting their words. They are—

*Beadle*, 231; *Busby*, 472; *Sandford*, 596; *Walter*, 733; *Egerton*, 953; *Hind*, 1122; *Cobb*, 1216; *Savery*, 1447; *Hathaway*, 1524; *Farthing*, 1622; *Thorne*, 1748; *Brill*, 1932; *Young*, 2006; *Hoskins*, 2331; *Faulkner*, 2439; *Harling*, 2527; *Gatward*, 2682; *Showell*, 3366; *Showell*, 4348; *Armitage*, 4502; *Plumb*, 4652; *Martin*, 4698; *Brown*, 4759; *Passfield*, 4965; *Capt. Jan Visser*, 5213 *Capt. Marsden*, 5356; *Capt. James*, 5744; *Young*, 6148.

Many more witnesses to the same effect were offered: see Appendix CC.

117. These facts were admitted by the respondents, but the effect was attributed by them, not to the noxious qualities of the sewage, but to the absence of oxygen, which had been abstracted from the water in effecting the purification of the sewage.

Without deciding whether this is the true or the only explanation, the facts remain, that the fish have disappeared from this part of the river, and that their disappearance is due, either directly or indirectly, to the sewage discharge.

No evidence has been given before us to prove the actual loss sustained by any parties from this, but it must be to some extent an evil, and it should not be lost sight of, if the possibility of remedy is inquired into. Indeed, broadly speaking, if fish cannot live in a river, such river cannot be in a natural or satisfactory condition.

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## (D.)

### Pollution of Wells near the River.

118. Another ground of complaint brought before us has reference to the possible pollution, by the sewage, of wells on the shore in the neighbourhood of the outfalls. It is said that under certain circumstances, the water of the Thames may flow into the permeable strata from which such wells are fed; and it is argued that when the Thames water is fouled by sewage the pollution may penetrate into the wells, and so produce serious consequences.

119. The following evidence bears on this point.

*Whitaker* (*F. G. S.*), 6986, &c.—In the lower Thames, near the outfalls, the strata are chiefly permeable.

Therefore, there is plenty of opportunity for the infiltration of water from the river into the beds from which water may be drawn for supply.

And if that water is charged with sewage, such water must be infected therewith.

If a large supply is pumped from wells so situated, it will facilitate the contamination.

Two of the Kent company's wells have been discontinued on this ground.

The pollution would take time.

*Baldwin Latham*, 7944 to 7975.—In his judgment, the discharge of the sewage is likely to affect the wells in the neighbourhood.

Levels of all the wells at Grays were taken, and it was found that from the pumping which was going on, the water fell, and there was a direct flow from the direction of the Thames (which at that point has received the Metropolitan sewage) towards the spot.

Waters from wells in the neighbourhood have been analyzed and found to contain very much more chlorine than when the pumping was not going on. The quantity of chlorine varies with the state of the tide, there being a somewhat larger quantity at high than at low water.

Judging by the chlorine analyses it is inferred that on an average 23 gallons of river water are mixed with 1,000 gallons of the normal water of the district. One well shows 25 in 1,000.

120. The answer of the respondents is (*Law* 13,962–5) to the effect that the supply to such wells will be from the land, and not from the river;—that the water will run from the wells into the river, and not from the river into the wells.

We do not think this is always the case. As long as the water in the land strata adjacent to the river is undisturbed, it will stand at a level a little higher than that of the river, and so will tend to discharge into it. But when pumping goes on, the immediate effect is to lower the land water level for a considerable distance around, and consequently, under a lengthened action of this kind, there will be a tendency for the river water to enter the well.

It is known that fresh water obtained from wells in spits or banks of sand surrounded by salt water, or generally from land close adjacent to the sea, becomes brackish if the pumping from such wells is enough to lower the water considerably.

The Kent Water Company still draw water for the supply of the south-eastern districts of London from two wells at Charlton and three at Deptford, all within a short distance of the Thames. When they are pumping, the level of the water in these wells stands about 45 feet below mean tide level in the Thames,* and hence it appears possible that the river water, with any soluble impurity it may contain, might penetrate the permeable strata from which the supplies of those wells are drawn.

At the same time there is no evidence of any actual injury to health or property having arisen from this cause.

---

## (E.)

### The Formation of Shoals or Banks which might prejudice the Navigation of the River.

121. It is right to say that no complaint has been made before us on this ground. The Conservators of the Thames, who would be the proper complainants, have offered no evidence tending to show that any such shoals are at present in existence. But as fears on the subject are very natural, and as it is notorious that they have existed, and still exist, we do not feel justified in passing the matter over without observation.

122. In our historical notice we have already mentioned that two previous inquiries have taken place, in each of which this subject has formed an important feature.

In the Barking Inquiry, 1868, Mr. Rawlinson reported that the main channel of the Thames had not been reduced in depth of water by the detritus in the sewage; but he accompanied this judgment by remarks which showed that he considered there might be reasonable apprehension on the matter if the sewage continued to be discharged in its crude state.

123. The second inquiry, or, as it is usually called, the Mudbank Arbitration of 1879–80, has been especially and emphatically pressed on our notice by the Metropolitan Board, who appear to be under the impression that the decision given in that case must, for all time, absolve them from any liability to a charge of causing evils of the kind we are now considering.

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* Report of Royal Commission on Water Supply, 1869, par. 122.

As we have said, we have no evidence on which to form an opinion of our own on this subject. But assuming that the question is not a practical one at this moment, we should not like to say it never can become so.

The inquiry was confined to three particular banks, which had grown up within the last few years, and the decision was to the effect that these banks had arisen from the effect of dredging operations. The arbitrators called attention to a natural law in the phenomena of rivers, namely, that when the current was slackened by an enlargement of the sectional area, there was a tendency to the deposit of any solid matter held in suspension in the water; and as it was shown that dredging operations had been carried on to such an extent as to enlarge the areas at the places mentioned, the deposit of shoals followed as a matter of course.

124. But there is nothing in the grounds of this decision to render it impossible or improbable that the sewage discharge may, at some time, contribute materially to the formation of shoals in the river.

Experience shows that owing to the great irregularities in the movements of the water in tidal estuaries, the natural action may be powerless to maintain the channel unless aided by artificial measures; and there is no reason for considering the Thames as any exception to this rule.

When therefore it is considered that the sewage discharge, according to Dr. Frankland, adds to the river no less than a million and a quarter tons of mud every year (enough to fill up 300 yards of the river near the outfalls to low water level), it cannot be unreasonable that some alarm should be felt at the continuance of the process.

## CONCLUSIONS.

125. The following is a summary of the general conclusions we have arrived at in regard to the first two subjects of our inquiry.

1. That the works of the Metropolitan Board, for the purpose of carrying the sewage of London to the respective outfalls at Barking Creek and Crossness, have been executed in a highly creditable manner, and have been of great benefit to the metropolis. — Execution of works.

2. That the storm overflows allow the occasional discharge, into the river within the metropolis, of considerable quantities of solid fæcal matter accumulated in some of the sewers; but this has not caused, under present circumstances, serious damage or offence. — Storm overflows.

3. That the sewage from the northern outfall is discharged partly over the foreshore, and not, as was originally intended, "through submerged pipes terminating below low-water mark;" this arrangement increasing the risk of nuisance from the discharge. — Discharge from northern outfall.

4. That the discharge of the sewage in its crude state, during the whole year, without any attempt to render it less offensive by separating the solids or otherwise, is at variance with the original intention, and with the understanding in Parliament when the Act of 1858 was passed. — Crude state of the sewage.

5. That the discharge from the main outfalls becomes very widely distributed, by the motions of the water, both up and down the river, being traced, in dry seasons, through the metropolis, and almost as high as Teddington. And that it oscillates for a long period before getting finally out to sea. — Distribution of the sewage.

6. That the dilution of the sewage by the land and sea water, aided by the agitation produced by the various motions in the river, effects a partial purification of the sewage by oxidation. And that this purification is carried further by the action of animal and vegetable organisms. — Partial purification.

7. That the sewage, which becomes distributed to the higher and to the lower portions of the river, thus gradually loses its offensive properties. The limits, above and below the outfalls, where this purification becomes efficient, vary with the meteorological conditions; but it may be stated that, in general, above Greenwich and below Greenhithe, the river does not afford ground for serious complaint. — Limits where purification efficient.

8. That between these limits the effects of the sewage discharge are more or less apparent at all times. — Offensiveness between these limits.

9. That in dry seasons the dilution of the sewage is scanty and ineffective, especially at neap tides. — Scanty dilution in dry seasons.

10. That it does not appear that hitherto the sewage discharge has had any seriously prejudicial effect on the general healthiness of the neighbouring districts. But that there is evidence of certain evil effects of a minor kind on the health of persons employed on the river; and that there may reasonably be anxiety on the subject for the future. — Effect on health.

11. That in hot and dry weather there is serious nuisance and inconvenience, extending to a considerable distance both below and above the outfalls, from the foul state of the water consequent on the sewage discharge. The smell is very offensive, and the water is at times unusable. — Nuisance and inconvenience.

12. That foul mud, partly composed of sewage matter, accumulates at Erith and elsewhere, and adheres to nets, anchors, and other objects dropped into it. — Foul mud.

13. That sand dredged near the outfalls, which used to be obtained in a pure state, is now found to be so much contaminated with sewage matter as to be unusable; compelling the dredgers to go farther away. — Dredging interests.

14. That for these reasons the river is not, at times, in the state in which such an important highway to a great capital, carrying so large a traffic, ought to be. — River not as it should be.

15. That in consequence of the sewage discharge, fish have disappeared from the Thames for a distance of some fifteen miles below the outfalls, and for a considerable distance above them. — Injury to fish.

16. That there is some evidence that wells in the neighbourhood of the Thames are affected by the water in the river; and, although there is no proof of actual injury due to the sewage, that anxiety may be felt on that point. — Injury to wells.

17. That there is no evidence of any evil results to the navigation of the river, by deposits from the sewage discharge; but that this discharge adds largely to the quantity of detritus in the river, and so must increase the tendency to deposit. — No evil to navigation.

18. That the evils and dangers are likely to increase with the increase of population in the districts drained. — Probable increase.

Remedies.

19. That it is desirable we should inquire further "what measures can be applied for remedying or preventing" the evils and dangers resulting from the sewage discharge.

Time for consideration.

20. That before we proceed to this further branch of our inquiry, we should allow some time for the consideration of this our First Report, and of the remedies which may be suggested for the evils we have pointed out.

All which we humbly certify to your Majesty, under our hands and seals.

BRAMWELL.
JOHN COODE.
C. B. EWART.
ALEX. W. WILLIAMSON.
F. S. B. F. DE CHAUMONT.
THOMAS STEVENSON.
JAMES ABERNETHY.

WILLIAM POLE, *Secretary.*
31 *January* 1884.

This Report is not signed by our colleague, Sir P. Benson Maxwell, who is absent from England on public duty. But the substance has been discussed with him, and he has written us the following letter:

DEAR SIR, November 27, 1883.

YOU are aware that owing to my absence in Egypt I did not hear the evidence on behalf of the Metropolitan Board or the observations of their Counsel. I afterwards read both, however; and assisted in the preparation of the Report about to be presented.

As again I am obliged to absent myself I shall be glad if my colleagues of the Thames Sewage Commission will express for me my entire concurrence in the Report.

Very truly yours,
P. BENSON MAXWELL.

Dr. Pole,
Secretary to Thames Sewage Commission.

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For Her Majesty's Stationery Office.
[21268.—1875.—1/84.]

69

# ROYAL COMMISSION ON METROPOLITAN SEWAGE DISCHARGE.

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# MINUTES OF EVIDENCE

TAKEN BEFORE

## THE COMMISSION,

## From July 1882 to July 1883,

TOGETHER WITH

## A SELECTION FROM THE APPENDICES.

AND

## A DIGEST OF THE EVIDENCE.

---

**Presented to both Houses of Parliament by Command of Her Majesty.**

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# TABLE OF CONTENTS.


| | Page. |
|---|---|
| LIST OF WITNESSES | iii |
| LIST OF WITNESSES (arranged in Alphabetical order) | vi |
| MINUTES OF EVIDENCE | 1 |
| APPENDICES | 687 |
| DIGEST OF EVIDENCE | 763 |

# LIST OF WITNESSES.

## General Evidence.

1st DAY.—*27th July* 1882.


| | Page. |
|---|---|
| Sir J. W. Bazalgette, C.B. | 1 |
| „ „ (Further examined, 32nd and 33rd Days) | 459, 473 |


## Case of the Complainants.


| — | Page. |
|---|---|
| **1st DAY.—*27th July* 1882.** | |
| C. Beadle | 11 |
| **2nd DAY.—*1st August* 1882.** | |
| C. Beadle | 12 |
| J. R. Busby | 16 |
| W. Sandford | 18 |
| Captain A. Morrel, R.N. | 21 |
| „ F. Walter, R.N. | 24 |
| „ A. Gillett, R.N. | 25 |
| **3rd DAY.—*4th August* 1882.** | |
| (Report, Dr. H. Leach) | 27 |
| ( „ Mr. W. H. Power) | 28 |
| W. Egerton | 30 |
| „ (VIII.) | 101 |
| M. Hind | 34 |
| W. Cobb | 37 |
| **4th DAY.—*15th November* 1882.** | |
| E. Savery | 41 |
| J. Hathaway | 45 |
| J. W. Farthing | 47 |
| Jas. Clarke | 49 |
| J. Thorne | 50 |
| Thos. Parkinson | 51 |
| **5th DAY.—*17th November* 1882.** | |
| W. Brill | 54 |
| Geo. Young (Fisherman) | 56 |
| Thos. H. Sibley | 58 |
| W. H. J. McKee | 60 |
| J. G. Lee | 61 |
| W. Hoskins | 62 |
| C. Faulkner | 64 |
| W. Harling | 66 |
| H. Clarke | 67 |
| **6th DAY.—*21st November* 1882.** | |
| W. Gatward | 68 |
| G. Roberts | 71 |
| E. A. Carttar | 75 |
| Geo. Mastin | 77 |
| Serjt. C. Gilham | 79 |
| Capt. G. B. Lynch | 80 |
| J. H. Showell | 82 |
| J. W. Rozier | 84 |
| **7th DAY.—*22nd November* 1882.** | |
| Capt. J. Hussey | 85 |
| G. F. Fuller | 88 |
| Captain M. Williams | 90 |
| „ J. R. Whitehorn | 92 |
| „ W. Shepherd | 94 |
| A. R. Edmunds | 95 |
| G. Saunders | 97 |
| Thos. Marshall | 98 |
| **8th DAY.—*28th November* 1882.** | |
| R. J. Naylor | 100 |
| W. Egerton (Second Examination) | 101 |
| J. W. Showell | 105 |
| W. Evans | 107 |
| Mr. F. B. Jessett | 107 |
| R. Armitage | 109 |
| Jas. Adams | 110 |
| Thos. Brown | 111 |
| R. Plumb | 112 |
| G. Martin | 113 |
| J. Tall | 114 |
| W. Brown | 114 |
| H. Evans | 114 |
| **9th DAY.—*29th November* 1882.** | |
| Rev. J. McAllister | 116 |
| H. Passfield | 121 |
| W. H. Lewis | 122 |
| Captain Jan Visser | 127 |
| H. Spadaccini | 128 |
| Captain R. Marsden | 131 |
| G. R. Showell | 133 |
| **10th DAY.—*5th December* 1882.** | |
| Captain J. Fitzgerald, R.N. | 134 |
| „ C. H. James, R.N. | 141 |
| Mr. W. Collingridge | 144 |
| Do. do. | 180 |
| (Further examined 29th Day) | 425 |
| Thomas Long | 154 |
| George Lamerton | 156 |
| **11th DAY.—*6th December* 1882.** | |
| W. Turnidge | 157 |
| George Young (Master of Steamer) | 158 |
| J. Phillips | 162 |
| Captain E. Burstal, R.N. | 166 |

| — | Page. |
|---|---|
| 12TH DAY.—12*th December* 1882. | |
| Captain E. Burstal, R.N. | 173 |
| E. Hughes | 179 |
| Mr. W. Collingridge (Further examined) | 180 |
| J. M. Mason | 185 |
| G. R. Mason | 187 |
| 13TH DAY.—13*th December* 1882. | |
| G. J. Symons, F.R.S. | 188 |
| W. Whitaker | 198 |
| E. Shand | 200 |
| H. Jones | 201 |
| Captain H. Webb | 202 |
| ,, Thomas Huntingford | 202 |
| E. Martin | 203 |
| 14TH DAY.—9*th January* 1883 | 204 |
| (*No Evidence taken.*) | |
| 15TH DAY.—23*rd January* 1883. | 205 |
| 16TH DAY.—24*th January* 1883. | 222 |
| 17TH DAY.—30*th January* 1883. | 239 |
| 18TH DAY.—31*st January* 1883. | 253 |
| 19TH DAY.—6*th February* 1883. | 266 |
| 29TH DAY.—13*th March* 1883. | 425 |
| Baldwin Latham | |
| 20TH DAY.—7*th February* 1883. | |
| J. Mansergh | 281 |
| 21ST DAY.—13*th February* 1883. | |
| J. Mansergh | 299, 308 |
| C. J. More | 305 |
| P. Birch (also 22nd and 23rd Days) | 310, 337 |
| 22ND DAY.—14*th February* 1883. | |
| P. Birch | 314, 337 |
| (P. Birch) further examined 23rd Day | |
| Professor W. C. Unwin | 320 |
| 23RD DAY.—20*th February* 1883. | |
| Professor W. C. Unwin | 328 |
| (P. Birch) | 337 |
| Mr. C. Meymott Tidy, M.A., M.B. | 339 |

| — | Page. |
|---|---|
| 24TH DAY.—21*st February* 1883. | |
| 25TH DAY.—27*th February* 1883. | |
| Mr. C. Meymott Tidy, M.A., M.B. | 341, 354 |
| 26TH DAY.—28*th February* 1883. | |
| Mr. C. Meymott Tidy | 367 |
| 28th, 29th, and 42nd Days, further examined | 401, 417, 622 |
| Professor Edwd. Frankland, D.C.L., M.D., F.R.S. | 378 |
| 27TH DAY.—6*th March* 1883. | |
| Professor E. Frankland | 380 |
| 28TH DAY.—7*th March* 1883. | |
| Professor E. Frankland | 395 |
| (Mr. C. M. Tidy) | 401 |
| Mr. John Thomas Way, F.C.S. | 401 |
| (and 30th Day). | 444 |
| Mr. Chas. William Heaton | 406 |
| 29TH DAY.—13*th March* 1883. | |
| Mr. C. W. Heaton | 412 |
| Professor R. B. Tuson | 416 |
| Mr. C. M. Tidy | 417 |
| Professor L. Beale | 417 |
| Mr. C. E. Bruges | 424 |
| ,, F. J. Short | 424 |
| Mr. Collingridge | 425 |
| Mr. Baldwin Latham | 425 |
| Professor W. H. Corfield | 427 |
| 30TH DAY.—14*th March* 1883. | |
| Professor W. H. Corfield | 433 |
| Mr. Benjamin Browning | 439 |
| Mr. Way | 444 |
| 31ST DAY.—10*th April* 1883. | |
| W. Hicks | 448 |
| W. Bound | 449 |
| W. Bradley | 450 |
| C. Wood | 450 |
| Geo. Custance | 451 |

## Case of the Metropolitan Board of Works.


| — | Page. |
|---|---|
| 31st DAY.—10*th April* 1883. | |
| Mr. Bidder's speech - - - | 452 |
| 32nd DAY.—11*th April* 1883. | |
| Sir Joseph Bazalgette - - - (*See also* 1st Day.) | 459 |
| 33rd DAY.—22*nd May* 1883. | |
| Sir Joseph Bazalgette - - - | 473 |
| Mr. G. Chatterton - - - | 485 |
| 34th DAY.—23*rd May* 1883. | |
| Mr. G. Chatterton - - - | 489 |
| Mr. T. Maxwell - - - | 499 |
| Mr. W. W. Coleman - - - | 501 |
| Mr. F. Lett - - - | 503 |
| Mr. A. Rowarth - - - | 504 |
| 35th DAY.—29*th May* 1883. | |
| Mr. Henry Law - - - | 506 |
| 36th DAY.—30*th May* 1883. | |
| Mr. Henry Law - - - (*See also* 39th and 41st Days.) | 524, 566, 597 |
| 37th DAY.—5*th June* 1883. | |
| Mr. J. W. Tripe - - - - | 537 |
| Mr. John Groves - - - | 548 |
| Mr. Conrad Grundtvig - - - | 552 |
| Mr. James Petrie - - - | 553 |
| Arthur Avent - - - - | 554 |
| 38th DAY.—6*th June* 1883. | |
| Mr. Andrew Wise - - - | 555 |
| Mr. John Dixon - - - - | 557 |
| Surgeon-Major C. W. Griffith - - | 558 |
| Captain Wm. Miller - - - | 559 |
| Mr. Edgar Doggett - - - | 562 |
| Mr. F. Mead Corner - - - | 563 |

| — | Page. |
|---|---|
| 39th DAY.—12*th June* 1883. | |
| Mr. Henry Law (cross-examined) - | 566 |
| Mr. Edward Easton - - - | 579 |
| 40th DAY.—13*th June* 1883. | |
| Mr. Edward Easton - - - | 581 |
| Mr. R. Gordon Tatham - - | 587 |
| Mr. Walter Dickson - - - | 589 |
| Mr. Wm. Joseph Dibdin - - | 591 |
| 41st DAY.—19*th June* 1883. | |
| Mr. Henry Law (recalled) - - | 597 |
| Mr. Wm. Joseph Dibdin - - | 598 |
| Mr. August Dupré - - - | 610 |
| 42nd DAY.—20*th June* 1883. | |
| Mr. August Dupré - - - | 612 |
| (Mr. C. M. Tidy) - - - - | 622 |
| Sir Fredk. Abel - - - | 622 |
| Mr. Augustus Voelcker, F.R.S. - - | 628 |
| 43rd DAY.—26*th June* 1883. | |
| Mr. Augustus Voelcker, F.R.S. - - | 629 |
| Mr. William Odling, F.R.S. - - | 632 |
| Mr. Henry Clifton Sorby, LL.D., F.R.S. - | 639 |
| 44th DAY.—27*th June* 1883. | |
| Mr. Henry Clifton Sorby, LL.D., F.R.S. - | 644 |
| Mr. Hugh Herbert Mason - - | 649 |
| 45th DAY.—9*th July* 1883. | |
| Mr. Bidder's speech - - - | 652 |


## Replies of the Complainants.

46th DAY.—11*th July* 1883.


Mr. Webster's speech - - page 666
Mr. Beaumont Morice's speech - - „ 681

# ALPHABETICAL LIST OF WITNESSES.


| Name of Witness. | Evidence. | | Digest Page. |
|---|---|---|---|
| | Day. | Page. | |
| Abel; Sir Frederick, C.B., F.R.S. | 42 | 622 | 861 |
| Adams; James | 8 | 110 | 783 |
| Armitage; Richard | 8 | 109 | 783 |
| Avent; Arthur | 37 | 554 | 851 |
| Bazalgette; Sir Joseph W., C.B. | 1, 32, 33 | 1, 459 | 830 |
| Beadle; Charles | 1, 2 | 11 | 767 |
| Beale; Professor Lionel S., M.B., F.R.C.P., F.R.S. | 29 | 417 | 824 |
| Birch; R. W. Peregrine | 21, 22, 23 | 310, 337 | 808 |
| Bound; Walter | 31 | 449 | 829 |
| Bradley; William | 31 | 450 | 829 |
| Brill; William | 5 | 54 | 774 |
| Brown; Thomas | 8 | 111 | 784 |
| Brown; William | 8 | 114 | 785 |
| Browning; Benjamin, L.R.C.P. Lond. | 30 | 439 | 828 |
| Bruges; Charles Ernest | 29 | 424 | 825 |
| Burstal; Captain Edward, R.N. | 11, 12 | 166, 173 | 794 |
| Busby; Joseph R. | 2 | 16 | 767 |
| Carttar; E. Arundel | 6 | 75 | 777 |
| Chatterton; George | 33, 34 | 485 | 837 |
| Clarke; Henry | 5 | 67 | 776 |
| Clarke; James | 4 | 49 | 773 |
| Cobb; W. | 3 | 37 | 771 |
| Coleman; W. Warman | 34 | 501 | 840 |
| Collingridge; William, M.D. | 10, 12, 29 | 144, 180, 429. | 790 |
| Corfield; Professor W. H., F.R.C.P. | 29, 30 | 427 | 826 |
| Corner; F. Mead, M.R.C.S., L.S.A. | 38 | 563 | 853 |
| Custance; George | 31 | 451 | 830 |
| Dibdin; William Joseph, F.C.S. | 40, 41 | 591, 598 | 856 |
| Dickson; Walter, R.N. | 40 | 589 | 855 |
| Dixon; John, M.D., &c. | 38 | 557 | 851 |
| Doggett; Edgar | 38 | 562 | 852 |
| Dupré; August, Ph.D., F.R.S. | 41, 42 | 610 | 859 |
| Easton; Edward | 39, 40 | 579 | 853 |
| Edmunds; Augustus Robert | 7 | 95 | 781 |
| Egerton; William | 3, 8 | 30, 101 | 769 |
| Evans; Henry | 8 | 114 | 785 |
| Evans; William | 8 | 107 | 782 |
| Farthing; James William | 4 | 47 | 772 |
| Faulkner; Charles | 5 | 64 | 776 |
| Fitzgerald; Captain James, R.N. | 10 | 134 | 789 |
| Frankland; Professor Edward, F.R.S. | 26, 27, 28 | 378 | 817 |
| Fuller; George Frederick | 7 | 88 | 780 |
| Gatward; William | 6 | 68 | 776 |
| Gilham; Sergeant Charles | 6 | 79 | 778 |
| Gillett; Captain Arthur | 2 | 25 | 769 |
| Griffith; Surgeon Major C.W. | 38 | 558 | 852 |
| Groves; John | 37 | 548 | 850 |
| Grundtvig; Conrad | 37 | 552 | 851 |

| Name of Witness. | Evidence. Day. | Evidence. Page. | Digest Page. |
|---|---|---|---|
| Harling; William | 5 | 66 | 776 |
| Hathaway; Joseph | 4 | 45 | 772 |
| Heaton; C. William, F.C.S. | 28, 29 | 406 | 822 |
| Hicks; William | 31 | 148 | 829 |
| Hind; Michael | 3 | 34 | 770 |
| Hoskins; William | 5 | 62 | 775 |
| Hughes; Edwin | 12 | 179 | 795 |
| Huntingford; Captain T. | 13 | 202 | 797 |
| Hussey; Captain James | 7 | 85 | 779 |
| James; Captain C. H. | 10 | 141 | 790 |
| Jessett; Frederic Bowreman | 8 | 107 | 783 |
| Jones; Henry | 13 | 201 | 796 |
| Lamerton; George | 10 | 156 | 792 |
| Latham; Baldwin | 15, 16, 17, 18, 19, 29 | 205, 425 | 797 |
| Law; Henry | 35, 36, 39, 41 | 506, 556, 566, 597 | 841 |
| Lee; John Godfrey | 5 | 61 | 775 |
| Lett; F., M.R.C.S. | 34 | 503 | 840 |
| Lewis; William Henry | 9 | 122 | 786 |
| Long; Thomas | 10 | 154 | 792 |
| Lynch; Captain G. Benjamin | 6 | 80 | 778 |
| McAllister; Rev. John | 9 | 116 | 785 |
| McKee; William Henry Joseph | 5 | 60 | 775 |
| Mansergh; James | 20, 21 | 281, 308 | 805 |
| Marsden; Captain Richard | 9 | 131 | 788 |
| Marshall; Thomas | 7 | 98 | 782 |
| Martin; Edwin | 13 | 203 | 797 |
| Martin; George | 8 | 113 | 784 |
| Mason; George Robert | 12 | 187 | 795 |
| Mason; Hugh Herbert, M.R.C.S. | 14 | 649 | 866 |
| Mason; James More | 12 | 185 | 795 |
| Mastin; George | 6 | 77 | 778 |
| Maxwell; Theodore, M.D. | 34 | 499 | 839 |
| Miller; Captain William | 38 | 560 | 852 |
| More; Charles James | 21 | 305 | 807 |
| Morrel; Captain Arthur, R.N. | 2 | 21 | 768 |
| Naylor; Richard John | 8 | 100 | 782 |
| Odling; Professor William, F.R.S. | 43 | 632 | 863 |
| Parkinson; Thomas | 4 | 51 | 773 |
| Passfield; Henry | 9 | 121 | 786 |
| Petrie; James Edward | 37 | 553 | 851 |
| Phillips; John | 11 | 162 | 793 |
| Plumb; Robert | 8 | 112 | 784 |
| Roberts; George | 6 | 71 | 777 |
| Rowarth; Alfred | 34 | 504 | 841 |
| Rozier; James William | 6 | 84 | 779 |
| Sandford; William | 2 | 18 | 768 |
| Saunders; George | 7 | 97 | 781 |
| Savery; Edwin | 4 | 41 | 771 |
| Shand; Edgar | 13 | 200 | 796 |

| Name of Witness. | Evidence. Day. | Evidence. Page. | Digest Page. |
|---|---|---|---|
| Shepherd; Captain Walter | 7 | 94 | 781 |
| Short; Frank Job | 29 | 424 | 826 |
| Showell; George Robert | 9 | 133 | 788 |
| Showell; James Henry | 6 | 82 | 779 |
| Showell; John William | 8 | 105 | 782 |
| Sibley; Thomas Harry | 5 | 58 | 775 |
| Sorby; H. C., F.R.S. | 43, 44 | 639 | 864 |
| Spadaccini; Henry | 9 | 128 | 787 |
| Symons; G. J., F.R.S. | 13 | 188 | 795 |
| Tall; John | 8 | 114 | 785 |
| Tatham; Robert Gordon, M.R.C.S. | 40 | 587 | 855 |
| Thorne; John | 4 | 50 | 773 |
| Tidy; C. Meymott, M.A., M.B. | 23, 24, 25, 26, 28, 29, 42 | 339, 401, 417, 622 | 812 |
| Tripe; John William, M.R.C.P. Edin. | 37 | 537 | 848 |
| Turnidge; William | 11 | 157 | 792 |
| Tuson; Professor R. V. | 29 | 416 | 824 |
| Unwin; Professor W. C. | 22, 23 | 320 | 809 |
| Visser; Captain Jan | 9 | 127 | 787 |
| Voelcker; Augustus, F.R.S. | 42, 43 | 628 | 863 |
| Walter; Captain Frederick, R.N. | 2 | 24 | 768 |
| Way; Mr. John T., F.C.S. | 28, 30 | 401, 444 | 821 |
| Webb; Captain Henry | 13 | 202 | 797 |
| Whitaker; William, B.A., F.G.S. | 13 | 198 | 796 |
| Whitehorn; Captain Joseph R. | 7 | 92 | 780 |
| Williams; Captain Michael | 7 | 90 | 780 |
| Wise; Andrew | 38 | 555 | 851 |
| Wood; Charles | 31 | 450 | 829 |
| Young; George (Fisherman) | 5 | 56 | 774 |
| Young; George (Master of steamer) | 11 | 158 | 792 |

# MINUTES OF EVIDENCE

TAKEN BEFORE

# THE ROYAL COMMISSION ON METROPOLITAN SEWAGE DISCHARGE

AT THE

## House of Commons Committee Room, No. 11.

## FIRST DAY.

**Thursday, 27th July 1882.**

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
PROF. ALEXANDER WM. WILLIAMSON, PH.D., F.R.S.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst. C.E.
WM. POLE, Esq., F.R.S., *Secretary*.

Mr. WEBSTER, Q.C., Mr. LUMLEY SMITH, and Mr. BALFOUR BROWNE appeared as Counsel on behalf of the Corporation of the City of London, instructed by Sir THOMAS NELSON.

Mr. BIDDER, Q.C., Mr. MICHAEL, Q.C., and Mr. NORMAN BAZALGETTE appeared as Counsel on behalf of the Metropolitan Board of Works, instructed by Mr. REGINALD WARD.

Mr. BEAUMONT MORICE appeared as Counsel on behalf of the General Committee for the Protection of the Lower Thames from Sewage Pollution, and other local authorities and bodies, instructed by Messrs. NEWMAN, STRETTON, and HILLIARD; also on behalf of the Erith Local Board, instructed by Mr. PARISH.

Sir JOSEPH WILLIAM BAZALGETTE, C.B., called in and examined.

*Sir J. W. Bazalgette, C.B.*

27 July 1882.

1. (*Chairman.*) Perhaps the shorter way would be for you to make your own statement first, and upon that we can ask you any question?—Before I begin to describe the works which we have carried out for the interception of sewage from the river, I would like to refer shortly to what has rendered those works necessary. The Thames is situated in the bottom of the London basin, Highgate and Hampstead forming the rim of the basin upon the north, the rim upon the south side being somewhat further distant, namely, the Surrey hills. Into that basin the rain water flows from those hills through riverlets and brooks down to the Thames. In the first place upon the north side there is the Eel Brook, then the Ranelagh, the Stamford Brook, and the Brook Green Sewer. I am not going through all of them, but will take a few of the leading ones. Then there are the King's Scholars' Pond, the Fleet, the London Bridge Sewer, the Irongate Sewer, and the Ratcliffe Highway Sewer. Now these are all streams which flow from that high ground into the Thames.

2. You have some upon the other side also; will you mention those?—Yes, we have some upon the other side. I should mention the Falcon Brook, the Effra, the Duffield, the Earl, and Great St. John's.

3. And the Ravensbourne; does that also flow into the Thames?—The Ravensbourne River is also now converted into a sewer by Act of Parliament. These riverlets flowed from the high ground down into the low ground, which is considerably below the level of high water; and therefore when the tide was up, (and at one time the tide flowed all over that low ground, but it has since been embanked), and when it flowed up these streams, in times of heavy rain these riverlets overflowed the low ground. At that time before the general introduction of waterclosets, the sewage went into cesspools, and it continued to do so until it was found that the introduction of waterclosets rendered that almost impossible. Then overflows from these cesspools into the sewers were for the first time permitted. I should mention that when those sewers were brooks, at first it was penal to discharge any sewage into them; but it was found necessary then that a change should take place. Eventually it was found that the cesspools were sources of disease. They had become so numerous that when one cesspool was filled, instead of emptying it persons would fill it up and have another, and many houses had two or three cesspools under them, which gave rise to disease. Then about the year 1847 that was found to be so inconvenient that it became the law that everyone should drain his house into the sewer, and at that time there were some 30,000 cesspools destroyed, the houses being connected with the sewers. Then these open sewers had to be covered and were carried as covered sewers into the river. They discharged, passing through this low ground, at the level of low water, so that they discharged their contents into the river at the worst period as far as the sanitary condition of the river was concerned; firstly, because the sectional area of the river at low water is very much smaller than at high water, and secondly because instead of being carried by the ebb tide away from London the sewage was carried from low water to high water up the river. I have prepared a section of the Thames at London Bridge to show you the difference between the sectional area of the water at high water and at low water. The blue colour represents the water in the river at London Bridge at low water, and the upper line

*Sir J. W. Bazalgette, C.B.*

27 July 1882.

represents high water at Trinity, the high water being about four times or rather more than four times the low water area.

4. (*Mr. Michael.*) Then you have another line drawn which represents the Ordnance datum between the two?—I have.

5. (*Chairman.*) Will you hand that in?—I will, (*handing in the same. See Appendix A.*) Now putting a floating body into the river at high water as compared with low water makes really a difference of about 12 miles; that is to say if I put a float into the river 12 miles lower down below high water, it will have flowed up that 12 miles and will be in the same condition as if it had been put into the water 12 miles higher up at high water.

6. (*Chairman.*) Is that so, taking 12 miles above London Bridge?—No, I should say not 12 miles above London Bridge, because at 12 miles above London Bridge you get out of the tidal influence, but I am now speaking of from London downwards.

7. (*Sir J. Coode.*) Where do you assume the floats to be put?—I will assume somewhere opposite to London. Putting a float in 12 miles below London Bridge it will float up to London Bridge.

8. (*Chairman.*) Upon an average of tides?—Yes, upon an average of tides. The sewage, therefore, having been put for some years into the river at low water and flowing up, caused a nuisance to the river, which led to the formation of the Metropolitan Board of Works, in order to divert that sewage from the river. It was, I think, about the year 1855 that it was formed, and the first duty the board had to do was to consider how they could overcome this difficulty. Their difficulty was very greatly increased from the fact that, whilst the sewage was of a comparatively small quantity, and a tolerably uniform quantity, the rainfall was a very excessive quantity, and a very variable quantity; the rainfall at times in a thunderstorm amounts to an inch in an hour, and sometimes even to 2 and 3 inches, and we have had as much as 4 inches in an hour over parts of London. Now the maximum flow of the whole sewage of London does not amount to $\frac{1}{100}$th of an inch per hour in quantity.

9. Is that over the entire area?—Yes, over the entire area. The question, therefore, was how to deal with this variable quantity; a very great difficulty it always has been, and still continues to be. One proposal, and it is a plan which has been carried out in rural districts with success, was to separate the sewage from the rainfall, but in dealing with London that appears to be hardly practicable. There are 400,000 houses in London, and the adoption of such a plan would involve re-draining every one of those houses. You must put a drain into the house to take the sewage from the waterclosets and from the sinks, in fact, from the inside of the house; and you must carry the water from the roofs by another drain, separating the two from each house from the very commencement. Now, putting that reconstruction of all the drains of all the houses in London at 20*l.* per house upon the average, would make 8,000,000*l.* to begin with in the house drainage. Then it is not merely a question of money, but I think you would have a very powerful resistance to any such proposal. I think that every house in London having to be re-drained would, both on account of the expense and of the immense disturbance that would arise from it, be a proposal which would be very strongly objected to. Then that is not all. You would have to use the present system of sewers for the storm water, and to lay an entirely separate set of sewers through the streest for the sewage, with pumping establishments, and so forth. That we came to the conclusion could not be done; that, as it applied to London, it was an impracticable suggestion. Therefore we began to consider what the condition of the rainfall was, and it appeared from tables of rainfall that there were only from 14 to 21 days in the year on which the rainfall excedeed the rate of a quarter of an inch in 24 hours; therefore we said, if we can divert the sewage from the river in dry weather altogether on all those days excepting the 14 to 21 according to the season (a very wet season has been 30 days), we shall sufficiently divert the sewage from the river to make it clear; and that was the principle upon which we started, determining to divert from the present sewers which discharged into the river the whole of the sewage and a quantity equal to a quarter of an inch of rain running off with it. That was done by constructing lines of sewers at right angles or nearly so to this main valley sewer, which ran from the high ground down into the river, and we began by intercepting it at the upper points, so as to carry the sewage as much as possible to high water by gravitation in order to save pumping. In that way we commenced by constructing what we called the High Level Sewer upon the north side of the river, commencing at Highgate and Hampstead, passing down by the old Hackney Brook sewer, through Hackney and Stratford, over the River Lea, and by an embankment over the railways, down to Barking Creek. That goes past the pumping station, and is not affected by it. That sewer intercepts the sewage from an area of about 10 square miles. It commences by being 4 feet in diameter and is increased at the lower end, near the River Lea, to 9 feet 6 inches by 12 feet. Its fall at the upper end is 75 feet to the mile, and at the lower end 4 feet to the mile. Its length is about 7 miles.

10. Does it take anything from below it at all?—No.

11. There is not slope enough to take anything from below it, is there?—Yes it is deep enough to take in a little upon the south side of it. Perhaps I should explain here, that the sizes of the intercepting sewers being graduated to take the calculated quantity, that is to say, the sewage and the quarter of an inch of rain, whenever they are filled; near the top of them is a long weir, and the surplus water, when the rain exceeds the normal quantity, flows over this weir into the main sewer at a lower point. It runs from the main sewer (take the King's Scholars Pond Sewer, for instance), into the intercepting sewer, and then when that intercepting sewer is filled near to the top of the sewer, the weir, which is passed along the side of the sewer, allows the surplus to overflow, and it is carried by a branch into the lower part of the King's Scholars Pond Sewer. That is the principle upon which the storm waters are allowed to pass from the intercepting sewers down into the river.

12. It does not find its way into that main sewer again but into the sewer below it, is that so?—No, it goes into the sewer from which it has come.

13. And then discharges itself?—That is again intercepted by another intercepting sewer, and when it is filled the overflow again passes from it, and ultimately arrives at the river at the storm outlet. The Middle Level Sewer commences at Kensal Green, passing through Oxford Street, and nearly in a direct line down to the High Level Sewer near the River Lea, at Bow, and then the two unite, or are carried by two parallel sewers down to the outfall.

14. (*Sir J. Coode.*) They are quite distinct from each other after they join; they are two sewers parallel with each other, but distinct?—They are parallel, but at the same time having the means of communicating with each other, and so equalising the flow at the outfall.

15. (*Dr. Williamson.*) If you desire it, but ordinarily there is no communication?—No, the Low Level Sewer commences at the pumping station and passes at Pimlico along the Victoria Embankment, along the banks of the river, through the City, through Stepney, underneath the River Lea to the pumping station at Abbey Mills. I will describe the pumping stations together when I come to them. There it is lifted to the level of the High and Middle Level Sewers, and the three pass by three parallel sewers down to the reservoir at Barking. The Middle Level Sewer is 4 ft. 6 in. by 3 feet at the upper end, and increases to 10 ft. 6 in. in diameter at the lower end; its inclination varies from 17½ ft. in a mile down to a

minimum of 2 feet in a mile; the length of that is 11½ miles. The Low Level Sewer drains an area of about 11 square miles, it is 6 ft. 9 in. diameter at the upper end, 10 ft. 6 in. at the lower end, and its inclination varies from 3 feet to 2 feet per mile; it is 12½ miles long. Then there is the area beyond, containing Chelsea, Hammersmith, and Acton, which is at a low level, and that is termed the western division; it has a separate set of sewers passing through Chelsea from Hammersmith with a pumping station at Pimlico. There the sewage is lifted into the Low Level Sewer, and passes thence to the outfall through it. Upon the south side there is also a high level sewer with a southern branch, the Effra branch.

16. (*Chairman.*) Upon the north side, I may ask you whether anything to the westward of your system of sewers still finds its way to the Thames?—The pink line upon the cartoon represents the area of the metropolis.*

17. (*Sir J. Coode.*) That is the area for which the Metropolitan Board of Works are obliged to provide?—I should have stated that the Metropolitan Board of Works, constituted under the Act of 1855, had to intercept the sewage from the Thames, of a given area which is defined by the Act, and that area is represented by the pink colour upon the map.

18. (*Chairman.*) That is to say the pink lines?—Yes.

19. (*Sir J. Coode.*) North and south?—Yes, it contains 117 square miles. The whole of those works are laid out with regard to that area and nothing beyond it. The High Level upon the south side has a main line, and a high level branch which, together, intercept the sewage from 20 square miles. The route of those sewers is this; a branch commences at Dulwich, passes down to Peckham, and then to Deptford Creek, the main line commencing at Clapham, passing down through Brixton into the same creek. They pass under the creek by iron pipes and have an overflow for storm water into the creek, that is to say they are large sewers coming down to the creek, and at the creek they pass, with a grating at the bottom of them, through iron pipes into the outfall sewer; but when in times of storm that quantity is exceeded it rises up in pipes under pressure and opens some flaps into the creek, and the storm waters are thus discharged into the creek.

20. (*Chairman.*) It differs then, as I understand you, from what is upon the north side in this particular, that the storm water is not discharged into the intercepting sewer upon the other side of the interception, is it?—Yes, it is so in both.

21. And in addition, you have this contrivance at Deptford Creek?—Yes; and I should say that we have the same upon the River Lea for the Northern Outfall Sewer.

22. (*Sir J. Coode.*) How many storm discharges have you to the westward of Deptford upon the south side of the river?—Eleven. I will give you them in detail. Now the Southern High Level Sewer varies from 4 feet 6 in. by 3 feet, to two parallel sewers, each of them 10 feet 6 in. high and 10 feet 6 in. wide, with upright sides and a crown; the inclination varies from 30 to 2⅓ feet per mile, and the length is 13 miles. The Low Level Sewer on the south side commences at Putney, passes through Wandsworth, Battersea, Nine Elms, and Kennington, down to Depford Creek. The whole of the area between the Low Level Sewer and the river is exceedingly flat, and the sewer is very flat, and that is the reason why it is not carried along the margin of the river as is the Low Level Sewer upon the north side. The outfall sewer is 11 feet 6 in. in diameter, with a fall of 2 feet per mile. Now the pumping stations are, one at Crossness at the outfall upon the southern side with a lift from 22 to 33 feet, varying according to the state of the tide and the condition of the sewage, with a 500 horse-power pump and an auxiliary pump of another 500 horse-power used in time of storm. At Deptford Creek there is a lift from the Low Level Sewer into the outfall sewer of 18 feet, with engines amounting to 500 horse-power. At the banks of the Effra there is 200 horse-power provided for lifting the storm waters into the river in times of heavy storms, when they are penned up by the tide, and another at the Falcon Brook of the same power, which lifts varying from 6 to 12 feet. At Abbey Mills the lift from the Low Level Sewer into the outfall sewer is 36 feet, and the horse power provided is 1,140 horse-power. The western division is lifted into the Low Level Sewer 18 feet, with 360 horse-power, and an auxiliary of 120 in times of heavy rain. Althgether there are 3,520 horse-power.

23. That is to say nominal horse-power?—Yes.

24. Not indicated horse-power?—No, nominal horse-power. For the discharge of storm water into the river there are 35 outlets upon the north side, and 12 on the south. I have a list of them showing the sizes of each and the levels; but I may state that inasmuch as the levels of these storm outlets are so low, still, in times of heavy rain at high water when the outlets cannot discharge into the river the low districts are at times subject to floods. There have been serious complaints at Pimlico and at Battersea, where the surface of the ground is 5 or 6 feet below the level of high water, where some of the houses have basements, and the sewers are below those basements, that at the time of high water in a heavy flood they get overcharged, and the water rises into the basements.

25. You are speaking of the rising of fresh water?—Of the overflow of the sewers dammed up by the tide.

26. But the flooding is by fresh water, country water?—Yes. In order to get over that difficulty the Board of Works have determined to expend over a million and a half of money in constructing storm relief sewers. One of such sewers has been constructed in the Fleet Valley, upon the principle of making them perfectly water tight, having no communication with the low districts whatever; and acting as pipes under pressure. Those sewers go into the river 8, 9, or 10 feet in diameter. They have no connexion with the districts through which they pass, they are carried through the low districts up to higher ground, and then the storm waters which are poured into them charge them full until the waters rise to a higher level than the water in the river. Then that height of water upon them immediately creates a pressure and a discharge into the river.

27. (*Chairman.*) That is the intention?—That is the way in which they are designed.

28. It is not done yet, is it?—Yes, it is done in the Fleet Valley.

29. The effect of it is that you have a water-tight pipe, and the pressure of water at the upper end of it forces the discharge into the river?—Yes.

30. (*Sir. J. Coode.*) It overrides the tide as it were?—Yes; it has been done for some years in the Fleet Valley with very satisfactory results, and it is now being done at Vauxhall Bridge, where an enlarged storm outlet is being formed; one of them is being carried up through the low ground towards Clapham, and others are to follow.

31. (*Dr. Williamson.*) I understand that will provide only for the storm waters of the higher level of the basin?—Yes; At present the storm waters from the high level of the basin pour down to the lower part of the basin, and the water rises and floods the houses, the sewers being insufficient to carry it off. Now the proposal is to let the sewer in the basin carry off the water of its own district, but to let the storm outlets take into the river the storm water from the higher districts.

32. (*Sir J. Coode.*) The object being to relieve the lower lying districts from the pressure of storm water from the higher districts?—Yes.

33. (*Chairman.*) Then we neither send more nor less sewage into the river than goes there now?—Neither more nor less, it is to prevent that sewage

* The essential features of the cartoon referred to by this witness have been reproduced in the map, Appendix B.

*Sir J. W. Bazalgette, C.B.*

27 July 1882.

from being held underneath the houses and discharged at low water, and to enable it to go into the river at high water.

34. It will prevent the low districts being flooded with sewage and flood water mixed, and will send it into the river at once instead of allowing it slowly to soak into the river as it were?—Yes, that is the sole object of these sewers. I do not know whether I have sufficiently described the works of the intercepting sewers.

35. (*Chairman,*) Speaking for myself, I can only say nothing can be plainer.

36. (*Mr. Michael.*) Would you very shortly point out to the Commissioners the main sewers which are held under the Metropolitan Acts, in order that the Commissioners may have a conception of how the sewage gets into the main sewers?—The main sewers are those which I have been describing as the Ranelagh, the King's Scholars' Pond, and the Fleet, which run from north to south into the river, and which are intercepted by intercepting sewers.

37. Those are also under the Metropolitan Acts vested in the Metropolitan Board of Works, and are a portion of your system of sewerage?—They are. Perhaps I should explain that whilst the Metropolitan Board——.

38. (*Chairman.*) It would perhaps meet Mr. Michael's view if you would tell us what becomes of the sewage of any particular house?—It falls through its own pipes into the sewer of the street opposite to it, which is probably a district sewer.

39. Not belonging to you?—Not belonging to the Metropolitan Board of Works. I may explain that the Metropolitan Board of Works under the Act of 1855 has the charge of the main intercepting sewers which I have just described, and also of the main storm sewers called main sewers of Schedule D in that Act, certain sewers which are named. The district boards, some 40 in number, have charge of the branch sewers under the general control of the Metropolitan Board of Works. I should have stated that, in addition to the outfalls which I have referred to, there are still some few small sewers discharging into the Thames. We began to divert all those small sewers and drains upon the banks of the Thames, (any drain draining more than one house is called a sewer) to pick up the small sewers along the margin of the river, and divert them into the main intercepting sewers; but we were advised some three years ago that it was the primary duty of the district boards to deal with the small sewers, therefore we have served notice upon the district boards to divert the small drains into the intercepting sewers. To what extent that has been carried out I am unable to say at present.

40. Now I will ask you a question by way of illustration. Upon this south side of the river there may be some sewer falling into the Thames, as I understand, instead of falling into your intercepting sewer?—There are some houses upon the margin of the Thames having what really are drains, but which are technically sewers, passing still into the Thames. Now the outfall sewers all discharge into reservoirs, one at Barking and one at Crossness, the time of discharge commencing at high water, and continuing for four hours after high water. And I may say that the reason which induced the Metropolitan Board of Works to select those two points was, first, that on the north side of the river Barking could be reached by a large portion of the metropolis at high water by gravitation, and so reduce the pumping; and, secondly, because between Woolwich and Erith there is a length of six miles of river with nothing upon its banks but bone factories, artificial manure factories, glue factories, and works of an offensive character. There is no habitation to speak of upon that six miles, and there is no other point upon the river, until you get below Gravesend, where the same can be said of its banks. If you go below Erith you have Greenhithe, Purfleet, Grays, and Northfleet; and therefore to get as eligible a position as Barking and Crossness for the discharge of the sewage, it would be necessary to go below Gravesend, at least 15 miles lower down than we are now.

41. Now it may excite a smile, because it is manifest—anybody may make this observation,—you were going to commit a nuisance, and therefore you thought you would make it as little as possible; it is very unkind I know to say so?—No doubt that can be said, but the discharge of the sewage into the river was necessary, and it was a question where it should be discharged. Now if you are to discharge it 15 miles lower down, the least fall you could give to your sewer would be 2 feet in a mile; that means a depression of 30 feet for that 15 miles. A depression of 30 feet means lifting the sewage 30 feet. It also means that if you carry your sewer down below the bed of the river you can never discharge that sewer, in the event of the pumps breaking down, by gravitation; it can only be emptied at all by being pumped, and I estimate roundly that the cost of carrying two such sewers as we have for our southern outfall sewer for 15 miles, and lifting the sewage to the same height as it is discharged at Barking, would be at least 2,500,000*l.*

42. Including land?—Yes, including a small estimate for the land.

43. I suppose you would have to pay for the land?—We should have to a large extent to pay for land.

44. Could you do it for that?—I do not know that we could do it for that; it would be at least that, at any rate.

45. It is almost all hills upon the south side to Gravesend, sand hills first, and chalk hills afterwards?—I do not give this as an exact estimate. I have taken as a basis the cost of constructing the sewer through Plumstead Marshes, which was about 40,000*l.* per mile; and I say the continuation of the necessary intercepting sewers for both sides of the river, for 15 miles, would cost from 2,500,000*l.* to 3,000,000*l.*, with the requisite engines, buildings, and reservoirs.

46. And the expense of the pumping?—The expense of the pumping would be about 50,000*l.* a year, which, capitalised, would represent about 1,000,000*l.* and which is not included in the foregoing figures.

47. (*Mr. Michael.*) I do not think you have given the quantity of sewage you deal with on both sides of the river?—I am going to do that.

48. (*Chairman.*) What was the cost of the works generally which you proposed?—About 4,000,000*l.*

49. (*Sir J. Coode.*) That applies to the sewer works shown in red upon that map, and the subsidiary works, the system now in operation?—Yes, the system now in operation.

50. (*Mr. Michael.*) That is exclusive of all sewers belonging to the district authorities?—Yes, that applies to the main intercepting sewers; nothing that has been done to the Schedule D. sewers.

51. (*Mr. Abernethy.*) Not to the storm water sewers?—No; the 1,500,000*l.* that I mentioned would be in addition to that.

52. (*Chairman.*) Upon the Essex side it is marsh almost all the way down the banks of the river to Gravesend, except that at Grays or at Purfleet there is a little bit of hill?—That is so.

53. However, you have estimated the cost of carrying the outfall further down at 2,500,000*l.*?—I did not give that as an estimate, but rather as an idea.

54. You consider it would cost at least that?—Yes. Here is a map which will show Barking, Crossness, Woolwich, Erith, Purfleet, Grays, Thurrock, and Greenhithe (*handing in the same.*) That map shows a private scheme which was proposed some time ago for taking a portion of the sewage down the river and irrigating land with it.

55. (*Sir J. Coode.*) Fifteen miles lower down the river would bring you to what point?—To Tilbury Marsh, upon the north side, and the Mucking Flats upon the south. Now, in order to discharge the sewage at high water, and to take advantage of the ebb tides for carrying it away, we have constructed reser-

voirs, a reservoir at Barking covering about 9½ acres, and a reservoir at Crossness covering about 6½ acres.

56. (*Dr. Williamson.*) Of what depth?—I will give you the whole of the figures. Barking is about 11½ miles below London Bridge, and Crossness is nearly 13½ miles, or 2 miles lower down. I am going to give some of the levels in a little detail, because, I think, probably, the engineers upon the other side will want to know them, and it is as well to give them in the first instance. Trinity high water is 12 feet 5 in. above Ordnance datum; low water is 7 feet 6 in. below datum.

57. (*Chairman.*) Therefore there is a difference of about 20 feet?—Yes. I am taking an ordinary spring tide, a tide represented by Trinity high-water mark, which is not a high spring tide, but a moderate spring tide; therefore, half tide is + 1·56 — plus means over datum, minus means below. The bottom of the reservoir is + 2·75 feet or 1·19 feet above half tide; the bottom of the reservoir is therefore a little over one foot above half tide, that is at Crossness and Barking. These reservoirs, I should explain, are brick arched, covered over, and they have weirs at the height I give, so that when they are full there should be an overflow from them. The overflow weirs at Barking are 16·25 feet, or 3·75 above Trinity high water; the available depth, therefore, is 13½ feet. The overflow weirs at Crossness are 2·5 higher than at Barking, and the available depth at Crossness is 16 feet. The invert level of the northern outfall sewers where they come down to the Barking reservoir is + 11·4, so that the overflow weirs are nearly level with the mid height of the outfall sewers. The reservoir will begin to overflow when the sewer is running half full, it would rise up or be ponded up to half the level of the sewer; beyond that it would go off. Barking reservoir will contain 35,000,000 of gallons, or 5,600,000 cubic feet. Crossness reservoir contains 25,000,000 gallons, or 4,000,000 cubic feet, making together 9,600,000 cubic feet. Now, in 1878, the quantity discharged at Barking altogether, including rain, in 24 hours, was 13,120,000 cubic feet, which in the eight hours that the reservoir has to store it, would amount to 4,373,000 cubic feet.

58. (*Dr. Williamson.*) Is that in the course of the day?—No, in one tide; there are two tides of 12 hours. Now, if we are discharging only from high water for four hours, we must be storing for the remaining eight hours.

59. And if you are storing during that time you are emptying also, are you not?—No, we are storing then.

60. You must be, unless you have two reservoirs?—It is flowing into the river for four hours.

61. But it is flowing into your reservoir at that time too?—It is flowing through the reservoir.

62. But it is discharging more than has accumulated in eight hours?—Yes, it is discharging what has accumulated during the other four hours of that time.

63. (*Sir J. Coode.*) When you say, "including rain," what do you assume?—I am taking the average of the quantity that came down for the year 1878.

64. That is to say the yearly average?—Yes; so that we had at Barking to store 4,373,000 cubic feet. At Crossness the average sewage and rainfall discharge was 12,164,000 cubic feet, giving for eight hours' storage 4,055,000 cubic feet, equal to a total of 8,428,000 cubic feet from the two reservoirs in the eight hours. I have just stated that the storage capacity of the reservoirs was 9,600,000 cubic feet, so that we had a little margin there; but I have not got the actual quantity since 1878, but it appears that in the four years before 1878 the average increase was 14 per cent.; therefore I have taken four years since 1878, and assumed that the increase has been as great, although I do not think it has been quite so much, for the year 1878 was a very wet year; however, I have taken it out and reasoned upon that assumption.

65. You say "the daily average over the year," then do you take the total annual rainfall and assume that to be distributed equally over the whole 365 days?—No, we have measured the quantity actually coming down.

66. But that is the average over the whole year?—Yes.

67. What was the maximum is the question we have rather to deal with than the average.

67*a*. (*Mr. Abernethy.*) Is that exclusive of what flows over the storm weirs?—No, that takes in the storm weirs.

68. (*Sir J. Coode.*) When you give us the average, it does not show what the maximum would be?—It does not.

69. (*Chairman.*) You say you discharge from these reservoirs for four hours?—Yes.

70. Can you empty them?—Yes, they are quite empty at every tide, the bottom of them is above the level of half tide. When the tide has fallen half way it is below the bottom of the reservoir, the sewage is stopped up much above high water, so that the moment the sluices are open at high water there is a rapid discharge down to the level of high water.

(*Sir J. Coode.*) What the noble chairman is trying to arrive at, if he will allow me to say so, is this, the relative area of the sewer as it enters the reservoirs and the discharging power of the reservoir itself.

71. (*Chairman.*) You have said that with the exception of the average of about 21 days in the year your sewers are so constructed as to take off the rain water and the sewage. I suppose you arrange your reservoirs in such a way as that they should be capable of receiving what the sewers are so capable of discharging?—No, that is not so, the sewers are capable of bringing much more than the reservoirs will hold; and when they are doing so there will be an overflow of the reservoirs just as there is an overflow at all the storm outlets.

72. Direct into the river?—Yes, we say that if storm overflows must be permitted in London itself, much less objectionable it would be to have storm overflows at Barking and Crossness, the lower down the river you can get them the better.

73. (*Chairman.*) It comes to this, that you may have an overflow at your reservoirs at the beginning of flood tide?—I am going to give you more information about that to show you what we propose to do.

74. But it is so, is it not?—As a fact on 43 days in the beginning of 1881 there were overflows from Crossness Reservoir at the time of flood tide. I have not the return from Barking, but I believe there were more days at Barking than at Crossness.

75. But it might be that sometimes your sewers would carry off all the rainfall, but your reservoir could not hold it, and then it comes up the river with the flood tide?—Yes. Now I was going on to argue that, supposing the increase in the quantity of sewage had gone on since 1878 as it did in the previous four years, we should have the quantities increased to the amounts that I gave. We should have now the quantity at Barking of 14,956,000 cubic feet, or in eight hours 4,985,000, and upon the south side we should have 13,867,000 cubic feet, and in the eight hours 4,622,000, or a total of 9,607,000 cubic feet. Now your Lordship will see that on the average that just balances what our reservoirs are capable of holding, and, as the flow is not even our reservoirs may be overcharged, and are overcharged at times even in dry weather.

76. How is that, supposing it has not rained for a fortnight for instance, could that occur?—Yes, it does occur sometimes even without rain; because in the middle of the day the flow of the sewage is greater than it is at night, or greater than the average flow, and, therefore, we sometimes get an excess and it overcharges our reservoirs. Now we had foreseen that difficulty, and the Board of Works were determined to enlarge their reservoirs to the amount of 50 per cent; that order was given some time ago. Contract drawings had been prepared, and they would

*Sir J. W. Bazalgette, C.B.*

27 July 1882.

have been enlarged at a cost of 160,000*l.*; but objections to the position of the outfalls having been raised, it was said, "This Commission may object to your outfalls altogether; it may object to your spending more money at those outfalls"; therefore the Board of Works have adjourned the construction of these additional sewers for three months, in deference to this Commission. The mean flow of the fresh water coming down the river is 84,500,000 cubic feet in each ebb tide.

77. Will you explain that a little more fully?—That is the amount of fresh water coming down the river.

78. The average contribution of the river to the sea, you may say?—Yes.

79. Where?—At Barking, for example.

80. (*Sir J. Coode.*) That, again, is the mean over the whole 12 months?—Yes, that is the mean. The discharge of tidal water past the outfall is 2,148,713,000 cubic feet, together making the water that flows down each ebb tide 2,233,213,000.

81. (*Chairman.*) That supposes, if I understand rightly, that the 2,000,000,000 is water which has been up and has come down again?—Yes, tidal water which has flowed up and come down again.

82. It is not up-land water or country water?—The 34,000,000 is the water above the tide, and the tide itself is the two thousand odd millions, together making 2,233,213,000.

83. So the fresh water would be about four per cent.?—Yes, speaking roughly.

84. What is the volume that you discharge at the two places?—14,000,000 for one tide.

85. (*Dr. Stevenson.*) Is the 14,000,000 the north or the south?—Both together. I do not know that I have any further statement to make.

(*Mr. N. Bazalgette.*) Will you explain to the committee for what reason the Board of Works decided upon the Crossness and Barking outfalls, having regard to the tidal action at those two spots.

(*Chairman.*) Sir Joseph Bazalgette told us that one strong reason was that for six miles down the river there were no habitations upon either side, nothing except bone factories and so on.

86. (*Mr. N. Bazalgette.*) Was there any further reason arising from the flow of the ebb and flood tides, will you, in short, explain to the committee what reason the Board of Works had, or what their *ratio decidendi* was, in selecting these two spots: was it in order that the discharge of the sewage at that point should not be carried up to the metropolis but should be taken away by the ebb?—A number of float experiments were made (assuming for the moment the sewage to be a solid block like a float) to ascertain what would be its action if carried down by the river two hours after high water. I will beg leave to read a record of those experiments. "On the 13th of July 1851 a float was put into the centre of the river opposite Barking Creek two hours after high water. This time was chosen because it was found that sewage discharged into the river two hours before high water arrived at about the same point above Barking Creek as sewage discharged two hours after high water did by the next flood tide. At low water the float reached $11\frac{3}{4}$ miles below thst point and returned with the next flood tide to one mile above, it having gone $12\frac{3}{4}$ miles that flood, it being then the period of spring tides. As the neaps came on the float continued to work lower down at each succeeding high water, and by the 24th of July it was 13 miles below Barking Creek at high water, having gone down the river 14 miles during the falling off of spring tides to neap tides. As the floods again became stronger it worked up the river each succeeding tide until the 29th July, when it again came within 5 miles below Barking Creek at high water, having worked up the river 9 miles from high water neap tides to high water spring tides, the excess of the ebbs over the floods being only 5 miles in 14 days. Another experiment was tried at the same place on the 6th of August 1851, it being then lowest neaps, and the float being put down two hours after high water. It worked up each succeeding high water till top springs on the 12th of August, when it reached $6\frac{1}{4}$ miles above Barking Creek at high water. The float then again worked down the river till the 20th of August, $9\frac{1}{2}$ miles below Barking Creek, being a distance of 16 miles during the falling off of spring tides to neap tides. The excess of ebbs over the floods would in this case have been about 7 miles in 14 days. The wind and other causes would vary the result, but it may be roughly assumed that a substance in suspension works up the river about 1 mile a day at each high water as the springs strengthens, and down the river 2 miles a day as they fall of." But of course we say that sewage put into the river would not be like the solid substance which was the subject of that experiment. If it were so, the effect would be when the sewage was discharged at London at low water and went up the river, and then came down again, and at next low water another discharge sent up to join it, and another and another, that you would get in a fortnight's discharge more sewage in the river than there was water, a complete concentration of sewage, in fact. That is, of course, if it remained sewage; and if it had been discharged at low water under these conditions we should have had in London a stream of sewage instead of a stream of water at low water, but for the chemical action which goes on (which will be explained by others better than I can explain it), such as oxidation, which destroys its character to a certain extent.

87. Then will you tell the Commission what the volume of the river is as compared with the volume of sewage discharged into it at the point of discharge?—I have given the figures; you may take it as 150 to 1.

(*Chairman.*) I think I made it out that it was 4 per mil.

88. (*Mr. N. Bazalgette.*) Now, first it becomes diluted and then oxydised, does it not?—I think I had better not speak to that, but will leave it to others who are better informed upon the subject.

89. (*Chairman.*) But I do understand you to say that the solid body, the float, that you put into the water and treated, no doubt, as fairly as you possibly could, when you put it in at the mouth of the sewage discharge (I do not know when it was discharging, but let us say at the dead of the neaps, as they call it) as the springs increased worked up the river about 9 miles?—About a mile a day, on the average.

90. I thought you made it out a little more?—That was so in one instance, but it was on the average up 1 mile and down the next week 2 miles a day.

91. So that, supposing sewage to act like the float that you put into the water, it would have got up about as far as Greenwich?—It would, about that; just about to Greenwich, which is seven miles from Crossness.

(*Mr. L. Smith.*) I would beg leave, instead of putting any questions which would be a criticism upon the system, to suggest some questions upon which we might ask for further information, and then when we have got the information and studied the figures, we might go a littte more into it.

Examined by Mr. Lumley Smith.

92. First of all in regard to the actual area which is drained on both sides of the river; you gave us, I think, the number of square miles which were drained upon the north and on the south, did you not?—Yes, I did.

93. Could you give me again, without trouble, the number of square miles you told us upon the north?—I think upon the north it is 53 square miles, and upon the south 66.

94. Then, in addition to the districts which you

have acquired within the area of the Metropolitan Board of Works, you are acquiring by Act of Parliament the right to drain into your sewers certain other districts, are you not?—No, I think not, when I say that, I should say that there is one exception, a district which was within the metropolis, an island in the metropolis, which, although it did not belong to it, was, by Act of Parliament, made part of the metropolis for drainage purposes, and allowed to drain into our sewer, but Acton and other districts surrounding London have made application to the Metropolitan Board of Works to take their drainage into our system, and that request has been invariably declined upon the ground that the system is laid out to receive the drainage of a given area, and that area cannot be extended.

95. Has not Acton been allowed to drain into the metropolitan system?—No, there are legal proceedings pending at the present time with reference to it.

96. As a matter of fact, does it now drain into the metropolitan system? Does not some sewage now come from Acton into the metropolitan area?—It does.

97. That would increase the number of miles drained?—I do not think it would amount to a square mile.

98. Now with regard to South Hornsey, does not sewage from that district pass into the metropolitan area?—There may be some. Upon the margin there are districts which have the right of sending their surface water into the metropolis, and many of them make use of that right to turn in the sewage of their watercloset; we are using all the vigilance we can to prevent that, nevertheless I am not prepared to say that we have done it entirely; we have been from time to time endeavouring to stop it, and there are legal proceedings pending now.

99. If there were any addition to the sewage which comes from the outside districts, that would increase the quantity discharged. Now you gave us the actual quantity discharged in 1878?—I did.

100. And you were able to tell us that there had been an increase in the 14 years before 1878?—Yes.

101. And up to 1878 there had been a record kept each year of the discharge at Crossness and Barking?—Yes, up to 1878.

102. Has no record been kept since 1878?—Yes.

103. Then why are you not able to give us the actual discharge?—Because it has not been worked up. I have no doubt the materials exist for doing it, but I have not got them.

104. It seems to have been done every year up to 1878?—Yes.

105. So that the actual number of gallons that went into the river from Crossness and Barking was chronicled each year?—Yes, and I can get that; but may I be permitted to say that the main intercepting system was not really completed until 1874.

106. Will you tell me why it was not published year after year after 1878 as it seems to have been published before?—I think the Registrar General has it and can give it to you.

107. Then it is taken out year by year, and we can get at the number of gallons going in at Barking and Crossness?—Yes.

108. Because there has been an increase of building going on, I presume, in those parts of the metropolis?—We send a return to the Registrar-General of the quantities actually discharged at Crossness and Barking.

109. Then you can give the Commission your figures for the years after 1878, instead of basing your returns upon the figures of 1878?—No doubt I could do that.

110. Could you do it without any trouble?—Yes, it may take a little time to get out.

111. Your map shows in red the sewers which are the main intercepting sewers?—Yes.

112. Are those blue lines which have been pointed out the other sewers which existed before the intercepting sewers were made?—Yes they are.

113. Does your map show, in addition, the number of storm overflows into the Thames?—Yes it does. Everyone of the brown circles upon the river represents a storm overflow.

114. Those are all storm overflows; now is any record kept showing how often those are opened?—There is not a record kept as to all of them. I have a record of two of the principal, the one at Deptford Creek, and the one at the River Lea.

115. (*Chairman.*) They are not self-acting then, are they?—Yes they are self-acting. I have a return here of the number of days of overflow from the year 1872 to the year 1879 at Deptford Creek. In 1872 it overflowed 21 days; in 1873, 15 days; in 1874, 9 days; in 1875, 20 days; in 1876, 19 days; in 1877, 30 days, that being a very wet season; in 1878, 17 days; and in 1879, it overflowed 21 days, that of course was not during the whole day, but for part of those days.

116. (*Mr. L. Smith.*) What overflow was that?—Into the Deptford Creek, a large and important storm overflow for the Southern High Level.

117. That is a very important one, is it not—it is where the two sewers seem to meet?—Yes.

118. That is not self-acting, is it, but is opened by hand?—It is self-acting.

119. There are penstocks which are opened by hand and the water is let out, is not that so?—There is a lower flap which is not self-acting which is opened by hand, but when it fills the upper one is self-acting.

120. The bulk of the water comes out through the flap which is opened by hand, does it not?—No, the bulk comes out at the top when the sewer is full; the lower portion is only opened by hand when there is a very excessive storm, because the flaps above are sufficient to carry off the storm water.

121. Could you give us the number of times since 1879 that that has been opened at Deptford?—I have not got that, but I can supply it.

122. Now I will ask you one question as to the way in which the storm overflows act. When the High Level Sewer, as I understand you, gets flooded, it escapes over these weirs into the rectangle sewer?—Yes.

123. (*Chairman.*) But that will not hold it; it escapes over again?—Yes; that takes it from the high level to the middle level, and from the middle level again into the low level.

124. (*Mr. L. Smith.*) From the middle level into the low level, and from the low level into the Thames?—Yes, at low water or near low water.

125. I am speaking of the times of flood when it escapes through the storm overflows?—Yes.

126. It would be mingled water and sewage that would get through these?—Yes.

127. That may happen at any time of the tide?—Yes.

128. And with some of them that are self-acting, as I understand you to say, it would be penned back and the traps would not be lifted up?—They are all self-acting.

129. But can they act at any time of the tide?—No.

130. Are there occasions when they would be penned back?—Yes.

131. (*Mr. Abernethy.*) They would discharge at low water only?—Yes, and that is the reason for our constructing the storm relief sewers which I have described, of which I have a list here.

132. (*Mr. L. Smith.*) The question I am going to put to you is this; the number of gallons which are discharged at Barking and at Crossness would not represent the total quantity that gets into the Thames, you would have to add to that all that goes out of the storm overflows?—At the time of a thunderstorm they may be all of them acting together, but then as regards the admixture of sewage, it would be very highly diluted at those times.

133. At all events that would have to be added to the discharge at Barking and Crossness?—Yes, our great object is to get it into the river as quickly as possible to prevent its flooding houses.

134. (*Chairman.*) You are referring to the storm relief sewers?—Yes.

135. (*Mr. Lumley Smith.*) No record is kept or can be kept of the quantity that goes through the storm relief openings?—No.

136. Are there any pumping stations which are actually kept for the storm water?—Yes.

137. Which are they. I think you said Battersea and Nine Elms?—There are three besides the auxiliary

*Sir J. W. Bazalgette, C.B.*

27 July 1882.

one at Crossness, there is one at the Effra Creek, one at the Falcon, and one at the western pumping station.

138. Where do they pump to?—Into the river, so as to prevent the storm water being held at high water and rising so as to get up to the basements.

139. I suppose when they are pumped into the river the quantity pumped is known at the pumping stations?—That could be arrived at.

140. That would be a figure which could be obtained, showing the quantity which goes into the Thames there?—That would show the quantity pumped, but it would not show anything like the quantity dealt with, because the pumps in stormy weather would only deal with a very small quantity of the total water passing. I have entered into a calculation of what an inch of water over our 119 square miles would amount to, we had at one time rain falling at the rate of 4 inches in an hour.

141. Taking now the actual reservoirs at Barking Creek and at Crossness, you gave us the Trinity high water mark, did you not?—I did.

142. That is not the mean high water mark, is it. Could you give me the mean high water mark?—The mean would be the mean between springs and neaps.

143. It would be rather less, would it not, than your 12 feet?—Yes, it would.

144. I am told that it would be 10·7 feet above Ordnance?—Yes, I dare say it would be.

145. Now with regard to the outfall, can you tell us the actual time at which the sewage is discharged?—From high water to four hours after high water.

146. It begins at high water?—It does.

147. And goes on for four hours after high water?—It does.

148. Then by that time do I understand that the reservoir is empty, or that the operation is stopped?—The reservoir is emptied.

149. And it goes on really till the reservoir is empty, it is not that the servants of the company shut down the penstocks at all, but the process goes on until the reservoir is empty?—The reservoir has been emptied before the four hours are out, and it is flowing through the reservoir.

150. Is it the fact that the reservoir empties itself in that four hours, and that all the sewage which comes down in that four hours is allowed to run into the Thames?—The sewage in the reservoir at high water is higher than high water, therefore when we open the penstocks at high water there is a rapid discharge from the reservoir, it then falls nearly to the level of the tide, it then continues emptying the reservoir as the tide falls until the tide has fallen below the bottom of the reservoir. Then the reservoir is empty, and that in half tide would be about three hours. Then for the next hour it would be running through as it is coming, and then it is closed.

151. Is the practice then to close it?—Yes, the practice is then to close it.

152. Is there any record kept of the time of opening and closing at Barking?—Yes.

153. I am told that sometimes it is seen escaping after the four hours, that it is not actually shut; is that the rule?—I have heard that stated, and it was examined into; it was found that there was some little leakage at one time through one of the penstocks, and that was stopped; but I believe it is regularly attended to.

154. (*Chairman.*) I suppose if there were a considerable quantity of storm water coming down there in a day, so that you knew that if you shut your penstocks the only consequence would be that you would have an overflow, you would probably keep your penstocks open longer?—No, we should shut the penstocks all the same, and should allow the storm overflow to fall into the reservoir until it filled the reservoir, and then it would be above the weir, and pass over the weir and flow into the river.

155. It would be presumptuous in me to differ from you, but it seems to me that this might happen, that instead of continuing to discharge whilst there was a two hours' ebb to go on with, you would lose that two hours' ebb for discharge, and the overflow would not begin until after two hours of flood?—I do not quite understand your Lordship's question.

156. You can tell from the quantity of rain which is falling that there will be an overflow, and that your reservoirs will not hold all that the sewers will bring down?—We could hardly leave that to the judgment of the men who have the care of the penstocks.

157. But assuming this was the case, instead of shutting up your penstocks at two hours before the end of the ebb tide, and waiting for your overflow, which would perhaps begin almost as soon as the flood tide began, I should have thought you had better have taken advantage of the two hours of ebb that still remained?—But the difficulty in doing that would be in leaving it to the discretion of the men, we must have a rule to go by. And then this must be borne in mind, that when you have an excessive storm of this kind all the streams discharging into the Thames are swollen; the Thames itself is swollen, and it is a period when discharging into it is really no nuisance; if there is a nuisance in the river it will be found to be in dry hot weather and not in times of storms. I never heard any complaints at such times.

158. (*Mr. Abernethy.*) I think you stated that during dry seasons there was still very often an overflow?—We have an overflow sometimes in dry seasons, and our reservoirs were to be enlarged to meet that objection; in point of fact the reservoirs when constructed were constructed to last for a certain period, and if necessary to be added to from time to time.

159. (*Mr. L. Smith.*) It has been stated that the discharge was going on after four hours' ebb. I am told that upon the 30th of last June a discharge was found going on at Barking at a quarter past 7 in the evening, which was about six hours after high water?—I was not aware of that.

160. That would be contrary to your practice?—I would ask whether it was dry weather?

161. Upon that particular day I am told it was fine?—I should be inclined to think there was some mistake about that. I can only say our people have very peremptory orders about it; and whenever it has come to my knowledge that it has been let out at any other time I have given them a very severe reprimand. I see no object in anyone connected with the reservoir doing anything of the kind.

(*Chairman.*) I do not think we should report against them for a slip or two.

(*Mr. L. Smith.*) Certainly not; but I am told upon this particular occasion when the sample was taken the outfall was open at a quarter past 7.

(*Witness.*) I have said that our reservoirs are not sufficient now when we have a maximum flow, and I have advised the board to increase them. The only object they have in holding their hand (for the works were ready to be let), was, that it was stated in the public papers, that in the face of this inquiry we should be doing extremely wrong to go and spend the public money on these reservoirs, so the board said, very well, we will wait three months and see what the result will be.

162. You have additional land there, have you not?—We have.

163. Can you give us any information as to the quantity of land that you have upon each side?—Not at the moment, but we can furnish it, we have some acres to spare at any rate.

*Mr. L. Smith* applied for permission to further examine the witness at a future date.

Examined by Mr. Morice.

164. Can you tell us whether the sewage is discharged into the river before high water at any time or before the time you mentioned?—If the reservoir has been filled upon certain days that I have mentioned it would be.

165. I take it that in the instances where it has been filled by anything like an overflow, it is some time before high water?—I cannot tell at what time.

166. Is there any record kept of the time at which it would discharge when that was earlier than the ordinary time?—Yes.

167. And that can be supplied?—Yes.

168. Do you know whether it has taken place lately, very often?—I have stated that upon the south side it occurred on 43 days in the year 1881.

169. Can you tell us now what amount of solid matter, or anything connected with it, you consider to be the usual proportion in the sewage?—No, the chemist will tell you that.

Examined by the COMMISSION.

170. (*Chairman.*) If I understand rightly now your intention is that all the sewage of the area you are to drain should find its way into your reservoir, and be let out into the river at the beginning of the ebb, and for four hours afterwards?—Yes.

171. And if there were no storm water, but for the exception to which I will next call your attention, you calculate that your apparatus is sufficient?—Yes.

172. The exception is, that even now there is sometimes in dry weather, at a particular hour of the day, more than your reservoirs will hold until the time has arrived for emptying them?—I have said the quantity of the sewage has increased since we had our reservoir built, and that we have proposed to remedy.

173. You say there is another difficulty sometimes caused by there being a heavy rain and your reservoirs overflowing at unappointed times?—Yes, that is so.

174. They may overflow at any time from storms, and your sewage be carried up to London Bridge?—Yes, the storm water would, but at times of flood the sewage is very much diluted with the storm water.

175. Besides that, there are storm waters which find their way out in the way you describe from these different storm overflows, and that also falls in above London and below London?—It does the whole way down the river.

176. Besides that, there are still a few drains or sewers remaining which you have told the district people they must remedy?—That would be found to be very small indeed.

177. Then still further than that, there is such a thing, which you have indicated, as this, that you cannot say to people that they shall not discharge their storm overflow into natural outlets, such as, for example, the Wandle, between Carshalton and Croydon, and some people, as I understand you, have availed themselves of that opportunity to put sewage in?—They have.

178. You go to them and fight them under the Rivers Pollution Act, or something of that kind, I suppose?—No, under our own special Act, I think.

179. Or by the common law of the land that they have no right to commit a nuisance. Now are those all the ways in which sewage gets into the river?—Those are not the only ways, there is the sewage from Stratford immediately into the River Lea.

180. You do not drain Stratford?—No, it is outside the pink line; we have a pumping station upon the River Lea just outside our boundary (*pointing to the map.*) Then there is a little bit at North Woolwich, a few houses of which drain into the river, where the cost of carrying it to the outfall and pumping would be more than the houses are worth almost.

181. What is to be done there, are they to be allowed to continue?—There is another called Cold Harbour Sluice there, between the dock entrances, which cannot be connected with the sewers; then there are the Beckton Gas Works, which have an outfall; then there is the shipping of course upon the River Thames, their sewage goes in; and there is what comes in above our outfall.

182. Have you no means of resisting the Stratford sewage going into the Lea, and so into the river?—No, I believe we have no influence over that.

(*Mr. Michael.*) The Metropolitan Board of Works have no jurisdiction in that case.

183. (*Chairman.*) As I understand they have no jurisdiction as a Board, but would you not be able to get at them as a nuisance, although, perhaps, there might be a difficulty in proving that they were a nuisance?—I do not know how that would be.

184. At present you do not know that you have any jurisdiction or any power to prevent it?—We have not.

(*Mr. Michael.*) As far as the Metropolitan Board of Works are concerned, they have no jurisdiction; whatever jurisdiction there may be with regard to drains, that is vested in the district authorities under the Metropolis Management Act.

(*Chairman.*) I fancy there would be some common law remedy if it were a nuisance.

(*Mr. Michael.*) I am only addressing myself as to the jurisdiction of the Board of Works, not saying that there is not a remedy, but that the remedy is not in the hands of the Board of Works.

185. (*Chairman, to the Witness.*) Now I will ask you this question, and I assure you it is not with the view of propounding an opinion, because I have not one on the subject; but you say that the sewage is not like the solid float you put in the river, and that there is no reason to suppose that the sewage would go up in the same way that the float did, now is that so. You or whoever superintended the float took care that it was kept in mid stream?—Yes.

186. But may it not be that sewage comes out into the Thames at the time of low ebb or still water, and then it subsides and goes to the bottom, and then upon the return tide the water runs there and takes it further up; do you understand the point of my question?—Yes, I think we shall show clearly in the course of this inquiry exactly the line that the sewage discharge does take, and that at a very short distance below the outfalls it ceases to be objectionable. However that is a point of the inquiry which I would rather leave to other hands who can deal with it much more ably than I can.

187. You would say that however right you might be in saying yes, to the general question, yet that it is not so here?—That is so.

188. Now if I understand you rightly you might make another river half as big as the Thames to carry your storm water and sewage, alongside of it, but of course that would not be practicable, and the only way to entirely obviate the sewage getting into the river would be to let the storm water find its way into the river as of old, and have separate drains for the dry sewage matter; that could be done, I suppose?—It would be possible to do it.

189. But it is not impracticable altogether, is it?—It seems to me to be quite impracticable, as I stated, it seems to involve the re-draining of every house in the metropolis, and that would involve, in my opinion, an expenditure of 8,000,000*l.* to begin with, and such an interference with private rights and property, that I believe the nuisance of that would be far greater than the nuisance of allowing diluted sewage to go into the Thames in time of storms.

190. People might resist it, although I think they are so much used to the interference of Boards by this time, that they would look upon that as a necessary evil; but still, it would not be impractible beyond the expenditure of 8,000,000*l.* upon the houses and drains, and shutting off your storm water?—There are other difficulties connected with it. If you are going to have (which that would involve) a number of smaller branch sewers without rain water in them, it would render it necessary that you should have a greater fall in the sewers to keep up the flow, you would require more pumping stations.

191. You would not have current enough in the sewers?—No, you would have to establish pumping stations in different parts of London; it is so compli-

*Sir J. W. Bazalgette, C.B.*

27 July 1882.

cated and difficult a matter in my opinion that it would be impracticable.

192. Could you not flush them from time to time with the storm water?—No; I think if you flush them after you have once separated them you must do it by other means.

193. You could have an apparatus for the purpose of shutting off the storm water from the sewers when there was danger of there being an overflow, but that would involve a great many people having to pay attention to it, would it not?—If you close your storm overflows you would have to close your gulleys in the streets, and let the water flow down over the streets; and then by the time you got down to the low ground you would have a river flowing through the Strand and other places which would carry you away. We deal with storm water as a monster enemy which has to be got rid of as quickly as possible.

194. When you got it to your pumping station you said, I think, that 2,500,000*l.* would enable you to take it how far further down?—I said that from 2,500,000*l.* to 3,000,000*l.* would enable us to take the sewage, not the storm water, down the river 15 miles. I stated that there was no point within 15 miles that you could go to upon the river; if you go lower at all you must go 15 miles further.

195. (*Sir J. Coode.*) And then you are how many miles from the sea, in round numbers, about 15?—Yes, you would be 16 miles from Sheerness.

196. (*Chairman.*) That would undoubtedly free the metropolis from all your Crossness and Barking sewage, would it not?—Excepting in times of storm.

197. Then there would be the overflow water running, as you have described, but water coming from your outfalls would never find its way back to London?—No doubt.

198. It would find its way back to Gravesend, perhaps, some of it?—I think not, but a float would.

199. (*Sir J. Coode.*) There are 66 square miles upon the south of the Thames. Could you tell us how many miles will be below high water spring tides?—I could not tell you that.

200. Nor the number of inhabitants drained directly situated upon that area, would you be able to furnish that?—Yes.

201. And also upon the north side?—I could furnish that.

202. (*Chairman.*) I have one further question which I wish to ask you. You say that such people as the Acton people have no right to drain into your drains; would they not be content to pay you for the privilege, as indeed they ought to pay you, but at present they have not been rated to the making of the great sewer?—They are quite willing to make a contribution, but our answer is that our system has been designed for a given area, and that we cannot take them in. Our pumping stations are not big enough, and our reservoirs are not big enough, and altogether we could not take them in, in fact there is no limit. If you once begin to take outside districts in you may get up to the rim of the basin.

203. Taking in Harrow, for example?—Yes, Harrow, Hampstead, and Highgate, and upon the south side going much further back.

204. Upon the south side, if you went upon the chalk, you might go nearly as far as Reigate?—Yes.

205. (*Sir J. Coode.* Who can give us any more exact information as to the number of these small sewers draining into the Thames, you say you yourself are not in possession of the facts, could you indicate any authority or any official who could supply us with that information?—I think I could give you information as to what the number was five years ago.

206. And the number of inhabitants?— Yes, I think so; but what has been done since I should not be able to tell you, it would require a fresh survey of the river.

207. And those additional engines you spoke of at the pumping stations you regard as auxiliaries to be employed only in case of storm?—Yes.

208. (*Dr. Williamson.*) Is there in the construction of the sewers any arrangement for separating the solids which may be in the liquid, whether lighter or heavier than the latter?—There is every precaution taken to prevent solid matter getting into the sewers, first by careful scavenging, taking as much off the surface of the road as possible, and then by the gulleys by the side of the roads intercepting it again. If any quantity of solid matter does get into the sewers we have to take it out of the sewers, and that has to be done at very great cost, so that our great object is, naturally, to avoid letting solid matter get into the sewers.

209. But does not sewage normally contain some solids, do not the materials that have to be carried away contain solids in part?—Yes.

210. Does that go through the pump just like the liquid?—Yes, just the same.

211. The shingle and sand are the things that you try to keep out?—Yes.

212. (*Mr. Abernethy.*) I suppose many of the private drains that belong to the district authorities have very little fall to them?—There are some places where they have very little fall. If, for instance, you take the low districts between Deptford, Nine Elms, and Bermondsey, all that is a low district where there is a very little fall; but in the districts wherever there is a good slope to the land itself there is a good fall to the sewers.

213. In those cases of slight fall accumulation is likely to take place in the sewers in dry weather, is it not?—We do not find that accumulation takes place to any large extent now. I gave in a return of what actually gets into the sewer in the inquiry before Sir Charles Hartley.

214. In heavy storms everything is swept out of those sewers into the main drains and overflows, and would go into the river?—The first effect of a heavy storm is to wash away any deposit in the sewer, and then the water runs off completely clear.

215. It does not always follow that when a heavy rainfall takes place within the area indicated by the pink line, the Thames is in heavy flood?—That is to say you may have a thunderstorm that is local to the metropolis; you do sometimes, but as a rule in wet flow weather the Thames is in a state of flood.

216. (*Dr. Stevenson.*) With regard to the float, did you make any experiments with floats of different specific gravities to ascertain the velocity of the flow?—We did not upon that occasion, but experiments have since been made of the velocity at different depths.

217. And with different materials?—Yes, by sinking the body to a certain depth to ascertain what the difference in the surface mean velocity was. I should state that the floats, although having a head upon the surface were weighted to a considerable depth, so that they were affected by the whole depth of the tidal flow.

(*Mr. Michael.*) We shall give you full information upon that subject. We have divided it into sections as to width and depth.

218. (*Chairman.*) I suppose a good deal of that which is solid in its origin by the time it is washed out of your reservoir must get mixed up with the water as it were?—Yes, it does.

219. Do you have sometimes solid things such as bits of bone, and bits of iron, and things of that sort, which cannot be treated in that way, coming down the sewers occasionally?—We have very little of that kind of thing.

220. What happens to them when they do come down, do they find their way to Barking or Crossness?—As a matter of fact I do not think they do.

221. You do not know what becomes of them?—I do not know.

222. There are continual warnings put up that housemaids are not to throw anything but water down the sinks, and so on, which, I suppose, means that they do?—I presume, when that is done, they stick in the syphon trap, and the occupiers have to look out for that themselves.

(Further examination postponed.)

*Sir J. W. Bazalgette, C.B.*

27 July 1882.

(*Chairman, to Mr. Webster.*) Your point will be that the river is polluted?

(*Mr. Webster.*) I say, on behalf of the city, that there is below the outfalls, and to a certain extent above them, a very great pollution indeed, both by the deposit of the foulest matter, and also by the water itself being impregnated with sewage, and being at times exceedingly offensive. We also say (which is an incidental matter) that the water into which the sewage is poured is by the consequence of the system, (I do not say it is any fault of the Metropolitan Board of Works for the present purpose, but it is in consequence of the system adopted) already considerably polluted, and that, therefore, you have not sewage going into a comparatively pure water which would help to dilute it, but you have sewage going into water already contaminated to a large extent by the sewage from the metropolis, and that is one reason why the sewage is more a nuisance than it would have been if it went into comparatively fresh water or pure water. I say the pollution above Teddington or above Hammersmith is, comparatively speaking, immaterial. Your Lordship knows that a great part of the water that is supplied for the drinking of the metropolis is taken in at points very little above London; therefore, I do not think it will be contended that the sewage that goes in above Teddington is of much importance, but the sewage which is poured in from the metropolis before it gets down to the outfalls has a material bearing upon the question.

(*Chairman.*) It is some distance from Teddington to Hammersmith, you know. I do not know whether there are any sewage inlets there.

(*Mr. Webster.*) There are some, but substantially there is nothing of importance.

(*Chairman.*) What you say is that the river is a little, but unsubstantially, polluted before it comes into the area of the Metropolitan Board, but that pollution is so much more within that area as to make the river unfit to receive any further discharge, and that when the discharge is made at Barking into the river it goes into already very foul water.

(*Mr. Webster.*) Quite so, and then there will be something to be said as to the way in which the solid part of the sewage moves up and down in the water from Barking and Crossness.

Mr. Charles Beadle is called in and examined as follows:—

*Mr. C. Beadle.*

223. (*Mr. Morice.*) I believe you are a member of the firm of Beadle Brothers of Erith?—I am.

224. And you are also a commissioner, I believe, for the purpose of maintaining the wall of the river?—Yes.

225. How long have you known the river?—About 35 years.

226. Have you in the course of a large portion of that time had to go up and down the river a great deal?—I have.

227. Will you tell us when first you remember the river what was the state of the water?—It was clear and wholesome; fish could live in it.

228. How long ago was that?—It was 20 years ago.

229. Up to what time did it remain clear and wholesome?—Within the last 15 or 16 years.

230. (*Chairman.*) From where to where?—My knowledge of the river is more especially at Erith, and between Gravesend and London.

231. (*Mr. Morice.*) Do you know whether fish were caught in the river at Erith?—I have caught them myself.

232. How many years ago was that?—15 years ago, or 10 years ago I might say.

233. Do you remember whether there was any bathing in the river at that place?—Yes.

234. Was that at the same time?—It was later than that.

235. Do you remember when the outfalls were made?—I do.

236. What has been the state of the river since?—It has been growing gradually more dirty and more objectionable.

237. Have you ever caught fish in the Thames since?—Not lately.

238. Up to what time, as far as you remember, were fish caught it it?—I should say within 10 years.

239. In your knowledge was that part of the river at Erith particularly a good place for fish?—A very good place for fish when I first knew it.

240. (*Chairman.*) These works have been in operation more than 10 years, have they not?—I think the river was not charged with sewage to any great extent at first, it is gradually getting worse every year.

(*Mr. Bidder.*) I think the works were opened in 1864.

(*Mr. Morice.*) I shall show your Lordships that the river has been getting worse and worse, driving the fish farther down.

(*Chairman.*) There is a large volume of discharge, I presume, as London has increased.

241. (*Mr. Morice, to the witness.*) Have you noticed when on the river that there has been any disagreeable smell?—In hot weather there is a very disagreeable smell.

242. Have you noticed that particularly within the last few years?—Yes, more particularly with the last few years.

243. Does it get worse, or not?—Certainly, it gets worse.

244. Have you been in the habit of coming up the river from the Nore?—I have.

245. (*Chairman.*) Do they not catch fish, whitebait, in that neighbourhood?—It is all driven down to Sea Reach. I do not think there is a bit of it to be caught this side of Sea Reach.

246. (*Sir J. Coode.*) Driven down from where?—From Blackwall. When I first remember it, whitebait was caught at Blackwall.

247. Is it ever caught there now?—Never.

248. You mean to say the fish has been getting driven farther and farther down the river?—Yes, every year.

249. Is that within your knowledge?—Yes, certainly.

250. You are not a catcher of whitebait yourself?—No, but I have spent a great deal of my time upon the river.

251. (*Mr. Morice.*) Do you remember whitebait being caught off Erith and sent up to London?—Yes, I do.

252. Within what time has that been done?—Within the last 12 or 14 years.

253. Then coming up the river from the Nore will you tell us what you notice with regard to the state of the water?—It begins to get thick in the Lower Hope, the next reach to Sea Reach; it gradually gets worse until you reach the outfalls, which is, I should think, the worst place; then it begins to get better again until you get up to Greenwich, and before you come to London Bridge you come to very decent water again.

254. Then where do you say the worst part of the river will be as far as colour and smell are concerned?—From Blackwall to Greenhithe, I should say.

255. Have you noticed the river at the time when the sewage has been discharged into it?—Yes.

256. What is the state of the water there?—It is black, much like a sewer would be.

257. What is the time of the tide when the smell in hot weather is the worst?—From about half ebb to half flood, I should say, covering low water.

258. Do you notice anything beyond the smell of the water, do you notice any gas rising?—In hot weather it gives off a gas; the water turns black and

*Mr. C. Beadle.* 27 July 1882.

it gives off a gas from bubbles which have a disagreeable smell.

259. (*Sir J. Coode.*) Do you mean that you can see bubbles of gas rising?—Yes, you can, near the shore; you can see them break upon the surface of the water.

260. (*Mr. Morice.*) I believe you employ a good many men at Erith?—I do.

261. Have they to work at low water when there is a great deal of mud about?—They have.

262. Have you had complaints from them as to illness resulting from the smell?—I have had constant complaints.

263. They work in quite low water?—The vessels are allowed to ground, and the water leaves them, and the men have to work on the vessels with the mud under them.

264. What is the kind of mud depcsit there now?—It is black, disagreeable mud, quite unlike what it used to be.

265. Do you remember the bed of the river; that is to say, so far as the water would leave it before the sewage was discharged?—I do.

266. What kind of mud was it then?—Dark clay; it was not at all disagreeable, and worms would live in it then.

267. Are there any worms in the mud now?—I have not seen one for years.

268. I believe you had a steamer belonging to your firm sunk in the river a short time since?—We had.

269. She was raised, I believe, by the Thames Conservancy?—Yes, she was.

270. Did you find that there was a great deal of mud deposited in her?—Yes, a great deal.

271. What was that mud like?—It was very disagreeable; we had great trouble to get men to clear it.

272. Was there any smell with it?—A great smell.

273. I believe you have been upon the river a good deal during the last 25 years?—I have.

274. Have you noticed the drift of the tide, that is to say, how much a barge or a lighter would drift up and down with the tide?—Yes.

275. That is to say the extent to which she would go down upon an ebb tide?—Yes, I have.

276. Will you tell the Commission how far an empty dummy barge would go upon the ebb tide?—Do you mean from a given point to a given point?

277. Yes; take it from above the outlet; how far would it go down upon a spring tide?—It would go from Crossness outfall to Gravesend Reach. It would vary a little from tide to tide, because of course tides run at different paces, but that would be about the average.

278. Then it would meet the flood tide?—It would meet the flood tide.

279. Could you tell us how far it would go back then?—It would go back beyond the point it started from, all the time the tides were making.

280. At Erith there is a considerable bay, is there not?—A very deep bay.

281. And do you know whether the sewage matter at all collects in that bay and deposits?—It has grown up in the last 20 years 10 to 12 feet.

282. (*Sir J. Coode.*) In vertical height?—Yes.

283. When you say from 10 to 12 feet do you speak from actual measurement or merely from estimation?—I know of one buoy that was put in from 8 to 10 feet of water, and boats would float at it, at low water, drawing 8 or 9 feet, and that buoy is now out of water at low water.

284. (*Dr. Williamson.*) What is it there, sand?—No, mud.

285. (*Mr. Morice.*) The river makes eddies there does it not?—Yes, it does.

286. There is not the full strength of the tide right through the bay?—When the tide is running down a certain amount of water gets round the point, it eddies round, and a boat's head would turn up the river instead of down after rounding that point.

287. That is to say there is a kind of back water inside the bay?—Yes.

288. As I understand the sewage collects there and deposits upon the banks?—Yes, it does.

289. Does it remain upon the banks during the hot weather?—Yes.

290. Have you noticed any effects of the sun upon the bank?—It causes the matter to decompose and to give off a gas; that is what we suffer from most.

291. Do you know the causeway?—Yes.

292. Has there been any alteration with regard to that in the last few years?—That has been lengthened twice, if not more, and raised several feet within the last 20 years.

293. (*Sir J. Coode.*) How much has it been lengthened?—I should say 100 feet.

294. Do you mean upon each occasion?—No, altogether. I believe now they are obliged to have a floating one there, which lifts up and down with the tide, because it has been under the mud so many times, and it cannot be used without being moveable.

The witness withdrew.

Adjourned to Tuesday next at half-past 1.

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## SECOND DAY.

### Tuesday, 1st August 1882.

PRESENT:

SIR JOHN COODE IN THE CHAIR.

PROF. ALEXANDER WM. WILLIAMSON, Ph.D., F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
WM. POLE, ESQ., F.R.S., *Secretary.*

Mr. CHARLES BEADLE called again. Further examined by Mr. MORICE.

*Mr. C. Beadle.* 1 Aug. 1882.

295. You were telling the Commission on the last occasion that the causeway at Erith had had to be lengthened recently?—It had.

296. Can you tell us whether there is any alteration in the tide line at low water from what it used to be, say, from 10 to 15 years ago?—Yes, there is a considerable alteration.

297. How much would you consider it had altered?—I should think it had altered 150 feet further into the river.

298. That would be at low water mark?—Yes.

299. Was there any alteration, as far as you remember, before the period you are speaking about?—No, it remained about the same.

300. And from about what year do you date the difference that you have noticed?—It has been growing up for the last 15 or 16 years, more particularly the last 10 years.

Examined by Mr. Webster.



301. You spoke upon the last occasion when we were here about a smell, would you just tell us whether you were able at any time to detect the smell of anything which, in popular language, you could describe. What does it smell of; I do not mean chemically, but popularly?—It resembles the smell of a badly ventilated water-closet, if you go into it in the morning.

302. A sewage smell?—I should say decidedly so.

303. You spoke of the men complaining of the smell during their work, have you yourself experienced the smell at the time they have complained of it?—I have.

304. I mean so as to be able to state that it is not the mere imagination of the men?—Oh, dear no.

305. Have you noticed at any time whether the smell that they have complained of produced any feeling when you smelt it, any unpleasant sensation beyond the mere smell?—In hot weather I cannot stand it.

306. In what way cannot you stand it?—It produces a headache and makes me feel sick, so that I am obliged to go away.

307. There are only one or two other matters I wish to ask you about; you have spoken of the causeways having to be lengthened, and the increase of deposit and the extension outwards of low water mark. What has been the character of the deposit around the causeways and over the causeways and out towards low water mark?—A slimy black mud.

308. And of the same character throughout, as far as the extensions are concerned?—Yes.

Cross-examined by Mr. Michael.

309. As you have lived at Erith 35 years, I suppose you have made yourself acquainted, from time to time, with the state of the river?—Yes.

310. And you know what has taken place there?—I do.

311. I understand you to say that for a period of about 15 or 16 years, there has been an accumulation of mud upon the western side of Erith Reach, somewhere near Belvedere?—Upon the south side I ought to call it.

312. I will call it the south-west?—Yes, that is so.

313. Are you aware that at the very period you speak of, that is the commencement of the 16 years ago, operations were commenced for the purpose of dredging away a bank which existed and ran out almost into the centre of the reach in the shape of a point opposite Cold Harbour Point?—Yes, it is called Erith Rand.

314. Besides that is it not the fact that at the very same period dredging took place upon the piece which is called upon the chart Rands Hill?—Yes, it did.

315. Could you give the Commissioners the exact time when the dredging began on Erith Rand?—I could not.

316. I am informed that it is about 15 or 16 years ago?—I should take that to be about the time it was completed.

317. Upon the map which is before the Commissioners you see a point running out opposite Cold Harbour Point, and to the east you will see a shoal called Rands Hill, with 14 feet of water; before that period, am I right in saying that the set of the tide was to sweep round that bight to the south and thoroughly keep it clean?—I do not think the tide swept round there more then than it does now.

318. Upon what datum do you found that opinion?—Because the tide in the river goes from point to point; it goes to what they call Cold Harbour Point from the point they call Jennngtree Point.

319. Since these two shoals have been removed from the point, has not the tide swept round and hugged the southernmost shore?—It never has done so.

320. Antecedently to the removal of those shoals, did not the tide sweep round the southernmost part, that is the bight that is called the Erith Bight?—No, it never did.

321. Was there no deposit there?—No, there was no deposit like there is now.

322. Was there slack water there?—There was slack water there always.

323. Has there been no difference in the set of the tide since those two shoals, Rands Hill and Cold Harbour, have been removed?—No; the bank called the Rand, which is now removed, was below Erith, and therefore did not affect the tide above Erith in running out. (*The witness explains the facts upon the plan.*)

324. Since that time is it not the fact that the tide has been deflected more to the northernmost part of Erith Reach?—No, not in my time it has not.

325. Can you at all precise the time at which in this portion of the reach the deposit commenced; take any part you like to tell me; in what portion, and when?—The deposit has been more especially in the last 10 years, and it is going on faster now than ever it did before.

326. Is it exposed at any part of the tide?—It is exposed at low water, 150 feet farther out than used to be the case.

327. And what about the northernmost portion?—In the northernmost portion there is no difference.

328. Not in the bank or in the depth of water?—No.

329. So that while the deposit has increased upon the southern side, the northern portion has been unchanged?—Only in the Bights.

330. Upon the southern portion the deposit has taken place to the greatest extent?—Yes.

331. And you say it has extended also to the west and north; not upon the northernmost side, to the north of the portion that you are speaking of, but still upon the southern side of the river?—Not so much towards Purfleet as it is in the upper part of the bight.

332. Have you taken any samples of the mud that has been deposited?—I did bring up some with me to-day. I do not know whether they will be any guide or not.

333. Have they been examined chemically?—No, I took them this morning with some men.

334. In what do those deposits differ from ordinary Thames mud?—They are much dirtier, much more offensive, and when the sun is out, which is when we feel it most, they are much more offensive than any other mud I know.

335. Do you know any Thames mud which, when exposed to the action of the sun at mid-day, is not extremely offensive?—It never was so bad as it is now.

336. What was not?—The Thames mud.

337. But you said that there was not any mud there 15 or 16 years ago?—No, I do not say there was none.

338. Has it increased so much as to seriously interfere with your comfort?—It has.

339. Where do you reside?—My works are upon the river.

340. Where do you reside?—I live three miles from the river; three miles south of the outfall.

341. Am I right in saying that your residence is in a line almost directly south from that portion of the river upon which there are a great many manufactories?—Yes.

342. Are your observations taken of this very disagreeable smell upon the river itself, or at your own house three miles away?—Upon the river itself.

343. At all states of the tide?—At low water when the mud is exposed and the sun upon it, then it is we find the most inconvenience.

344. Then it is not the water but the mud that you

*Mr. C. Beadle.*

1 Aug. 1882.

complain of?—The water also gives off a disagreeable smell.

345. Then are you able to determine which is the worst?—At high tide it is not so bad.

346. When is it worst?—At from half ebb to half flood.

347. During that time it is exposed to the sun?—It is exposed to the sun.

348. At your house do you experience any bad smells?—We do sometimes.

349. What is the direction of the wind when you experience bad smells?—From the north.

350. It would then be blowing over from the direction of the following works upon the northern side; to begin with Messrs. A. J. Crossfield's manure works, do you know Messrs. Crossfield's works?—I know them all.

351. And the candle factory close to it, do you know that?—Yes.

352. Is any nuisance created by those works?—A very great nuisance.

353. Are you able by any delicate sense of smell to determine when the smell comes from the mud banks and when it comes from Messrs. Crossfield's manure works and the candle factory?—It is quite unmistakeable.

354. Do you think you could distinguish between the smell of the refuse of gas works and the sewage smell that you can detect upon the river?—There is no difficulty when you are on the river in distinguishing between the smells.

355. But when you are at your works on the river you are flanked on the one side by Messrs Crossfield's works and the candle factory, and exactly opposite between the Erith Marsh and the magazine, there is Johnsons fish manure works; do you know Johnson's fish manure works?—Yes.

356. Is that a very sweet smelling place?—No, it is very disagreeable.

357. Do you know Bevington's manure works, is that very delightful?—No, they are all very disagreeable.

358. Do you know Collinson's glue and manure factory?—Yes, that is very disagreeable too.

359. Then besides that there is the Belvedere Guano Works; is that a very delightful thing?—I do not think that is so bad as the others.

360. I understand you to say that "of the bad," the smell of Johnson's glue and manure works is about the "baddest"?—That is about the worst.

361. So that, when the north wind blows, you have the disadvantage of having the whole of the smell of these six works blowing down over your residence?—Yes; but that does not apply to the works because they are very much above the manufactories.

362. In spite of your acute discrimination of smells, are you positively able to say that it is not the odours from those six works which come up to your premises and make you sick, but the smell of the sewage in the river?—I think so.

363. I should like to know how you are able to discriminate. Now what is the name of your house?—It is called Beadon Well. (*The site was pointed out.*)

364. (*Chairman.*) Where you placed the pointer was west of Erith?—But we are talking of the outfall, my house is three miles south of the outfall.

365. (*Mr. Michael.*) Do you smell any disagreeable smell from the river or the mud at your house?—I never detected it at my house.

366. Only the disagreeable smell of the factories?—That is all. Only the disagreeable smell of the factories.

367. How many workmen do you employ at your works?—From 200 to 300.

368. Would you be able to mark upon the Ordnance survey where your house is (*handing a map to the witness*?)—(*The witness did so.*)

369. Are those men of yours constantly employed, or do they fluctuate?—We keep them constantly employed.

370. Are the same men constantly employed, is it a shifting labour or do you have the same skilled labour?—It is not any of it skilled labour, but we have usually the same men at work.

371. What sort of health do they enjoy?—Not very good; we have had more laid up in the last three years than ever before.

372. Are you aware that Erith itself enjoys the happiness of being one of the healthiest places in the kingdom?—I believe that the death rate is low.

373. And not only that, but do you not know that their death rate from diseases likely to arise from sewage poisoning, or what we call zymotic diseases (I daresay you have looked at the reports of your medical officer of health), is extremely low?—I believe it is.

374. So that in the first place you have an extremely low mortality; and when you come to dissect that mortality you find that the mortality from zymotic diseases is very much lower than from other diseases?—It is so.

375. (*Dr. de Chaumont.*) What is the nature of your works?—We employ screw steamers and unload the goods into trucks and send them into the interior, and the workmen are employed working on and over the mud.

376. (*Mr. Michael.*) Could you tell me how many days of the year your men have been away from alleged illness?—I cannot.

377. Do you keep any record?—No.

(*Chairman, to Mr. Michael.*) Did you elicit the date at which the dredgings were completed.

(*Mr. Michael.*) We are unable to find the date at the present time, but the dredgings were completed about the period when this gentleman says the deposit commenced 16 years ago; and of course what we venture to say is that the one thing was entirely consequent upon the other.

Re-examined by Mr. Morice.

378. With regard to that last point, up to what time recently has the deposit of the sewage been worse than it used to be; could you fix any time for it?—I think it is getting worse every year, considerably worse.

379. You said it had been worse the last 10 years?—I think each year now would double itself in the evil, that is to say, we get twice as much deposit this year as we did last, as far as I can find.

380. I understand you to say that the deposit of low water mud which you have seen is more above Erith than below?—It is.

381. Is the part which my learned friend has asked you about just above Erith, a part where there is quite a bay and still water?—It is.

382. (*Chairman.*) What particular part of the Reach does that answer apply to?—The top part of the Reach from Jenningtree Point down to the causeway, or a little beyond, (*explaining the same on the plan.*)

383. Has the set of the tide been altered in the eastern part of the Erith Reach?—I think not in the least.

384. But opposite Erith, I think I understand you to say at the causeway it has?—At the causeway the mud has been silting up during the last 15 or 20 years very badly.

385. (*Mr. Morice.*) Do I understand you to say that the worst part is from Jenningtree Point to Erith?—Yes.

386. Do you know a place called Church Hole?—I do.

387. Is it bad there?—It is silting up very fast indeed there.

388. And that is some little distance above the village of Erith?—It is half way between Jenningtree Point and Erith.

389. Is the sweep of the tide in the lower part of Erith Reach just above Erith on the south shore or on the north shore?—Upon the north shore.

390. So that the portion near the south shore at Erith and just above is more like slack water?—It is.

391. (*Chairman.*) Was that so before the tongue at Coldharbour Point was removed?—It always had been.

392. You think the removal of the tongue at Coldharbour Point has not influenced the set of the tide above it?—It has not influenced the set of the tide at all above it.

393. Do you think you have been sufficiently experienced in the navigation of the river to give us an opinion upon that point?—I have been upon the river all my life.

394. (*Mr. Morice.*) Do you know where the yachts lie in Erith Bay?—Yes, there are two stations, one at the Corinthian and the other off the pier.

395. Where is the Corinthian station?—Near Church Hole.

396. (*Chairman.*) Is that opposite Belvidere church?—No, it is opposite Erith church.

397. (*Mr. Morice.*) Do you know whether there is any tide running there much where the yachts lie?—There is not so much tide there; that is in the slack water.

398. Do you know, from being upon the river, what course vessels take going up and down the river at this point?—They keep well out in the stream there; they go from one point to the other; they keep as near to the point as they can for water.

399. I understand you to say that as far as you remember, the tide has always hugged the south shore coming round there?—No, it is slack water upon the south shore.

400. And therefore in coming round, whatever it may do below Erith, it does not sweep the bay?—It does not sweep the bay from Jenningtree Point to Erith.

401. When do you notice the sewage mud gives off the worst smell?—In hot weather the sewage mud gives off the worst smell; it seems to rise up into the water and turns the water all black, and gives off a gas of some sort.

402. At what time of the tide would that be?—At low water, and from low water to half flood.

403. Have you noticed whether in hot weather there is any sewage deposited upon the bank?—I have not noticed anything that I could call sewage; it seems to be washed up into a thick state and diluted very much with water.

404. With regard to the situation of your house, which you have been asked about; your private house is at a place, I believe, called Belvidere, a little above Erith?—It is at the back above Erith, called Beadon Well.

405. Would that be affected by the factories that you have been asked about?—It would be about the same distance from them as the works.

406. In what direction would your residence lie as regards the factories compared to your business works?—My house would lie about south from the factories.

407. Therefore, if the wind were blowing from the north you would be more likely to get the smell of the factories at your house than at your business place?—Yes.

408. Have you any doubt when you are at your business place as to the sewage smell you have told us about?—I have not any myself.

409. And I understand your place is right upon the river?—Yes.

410. At low water have your men to work practically over the mud?—Yes; we put the vessels up upon the mud and let the water leave them, and until the water comes up again the men are working over the mud.

411. I understand you to say your men have complained to you of being sick and feeling the effects of the sewage mud?—They have in hot weather, they can scarcely stand it.

412. How long have you been living at Beadon Well?—About eight years.

413. Where did you live before that?—I lived nearer the river, at Belvidere.

414. Did you feel any ill effects from living so close to the river?—We were not so very close to the river, that was about two miles off.

415. Did you notice any river sewage smell more than you do now?—No.

416. Then I understand you to say that it is at your works, which are upon the river, that you smell it so much?—It is.

417. With regard to those factories, you know them all, I believe, pretty well?—I do.

418. Is there any doubt in your mind as to there being no difficulty in distinguishing between the smells which come from them and the sewage smell?—None, whatever.

419. Have you ever bathed in the river at this point?—I have in years gone by.

420. Was it different then from what it is now?—Yes, very.

421. Have you bathed in it lately?—No, I have not.

422. Would you like to do so?—I certainly should not.

Further cross-examined by Mr. Michael.

423. Are you aware that people were bathing there yesterday?—Very possible.

Examined by the Commission.

424. (*Chairman.*) You told us that the tide did not sweep the southern side of the river from Jenningtree Point to Erith; do you intend that remark to apply to the whole of Erith?—It applies to all except that bit I have mentioned in the bight.

425. Have you had to keep the foreshore clear from the mud?—We have to keep a gang of men slushing it clear.

426. How long has the pier been erected?—Forty-five years.

427. Has it been the case all along that you have to keep a man there flushing?—No.

428. When did this accumulation first appear?—It appeared more particularly the last ten years; it is dreadfully bad just now.

429. You know the place intimately, I presume?—Yes.

430. Are you able to say that previously to that time there was no necessity for this flushing?—No, there was not. I have been in business 30 years at this point.

431. (*Dr. de Chaumont.*) Was it only the last year or two that you have been obliged to keep the place clear?—No, we always had a man in there to look after it, but these last two years it has been almost impossible to keep it clear.

432. (*Chairman.*) But you said that it was not necessary to do so a few years ago?—Not as we must do it now; we have to keep a gang of men sweeping it night and day.

433. (*Dr. de Chaumont.*) What was the nature of the operation that went on in previous years?—There has alway been a little mud in the river, but it was a different kind of mud, and very much less of it.

434. Does it differ in its consistence, in its thickness, from what it formerly was?—In the thickness of the deposit each tide, and it is a very different kind of mud; now it is a slimy, greasy kind of mud; it is a lighter colour when it first deposits, and after a short time it turns black and stains anything that touches it.

435. In the former kind of mud was there any smell?—Not at all; nothing more than any clay would have. I have brought up some samples of this mud if the Commission would wish to see it.

The witness withdrew.

Mr. Joseph Robert Busby called in, examined by Mr. Morice.

*Mr. J. R. Busby.*

1 Aug. 1882.

436. I believe you live at No. 59, Parrock Street Gravesend, and are a Trinity River pilot?—Yes.

437. How long have you known the River Thames?—I am now in my fortieth year on the river. I was not born upon the Thames, but I was brought up alongside of the Thames the whole of my life. I have been upon the water 40 years come April next.

438. You have been a pilot for about 21 years, I believe?—I have been a pilot for 21 years.

439. You remember the state of the river before the outfalls were opened?—Yes, I knew the river many years before that.

440. Will you tell us what was the state of the river between Woolwich and Gravesend before the outfalls were opened?—Thirty-nine years ago it was a most beautiful river, very clear and very clean, my tea was made of the water from the Thames both for breakfast and for tea, and for years I drank no other water; if you had gone in the steamboats which I was on, as a passenger, you would have had that water to drink.

441. At that time you say the river water was generally drunk on board the steamers?—Always, both by passengers and crew.

442. Up to what time did that continue?—Our vocation is so different at times that it is difficult to remember dates. I was in those steamers for 10 or 12 years; and then before I was a candidate for the Trinity House I had to go to sea for 12 months so that I cannot give the years exactly.

443. When did you notice any alteration in the state of the river?—In 1855; in 1856 it was worse; in 1857 it was very obnoxious; in 1858 it was dreadful, and in 1859 it was worse still. This was owing to the number of outlets, from Jenningtree Point to Blackwall. It was a very warm summer in 1859.

444. Since that time has there been any alteration at all?—In 1860 we had a very wet summer, and that made it somewhat better, because a wet season makes it different.

445. Have you noticed anything, taking from 1863 or 1864, in the part you mentioned between Woolwich and Gravesend?—Taking the river between Woolwich and Gravesend, in 1860 it was a very wet summer, and it was better, it is purer again this summer than it has been for a long time; in 1863 it was very fearful, and in 1864 the sewer opened.

446. Have you noticed any alteration of any kind in the state of the river from 1864?—Yes, these last four or five years, to leave Gravesend at 5 in the morning and to come up on board of a ship with a tug towing ahead of you to stir the water up is dreadful; from Erith to Woolwich is, I consider, the most obnoxious, and the largest cesspool in the world. I often hold my handkerchief to my nose for an hour together.

447. How long have you noticed it getting so bad as that?—I have come down with vessels even eight or nine years ago, and the mate has knocked the crew off work, as a rule now they generally pump with a hose on the deck, they do not clean it as they used to do, and the mate has very often knocked the men off from scrubbing the decks on account of the water being so filthy and black as ink. I have seen that myself, that the mate has knocked them off and let them begin again in Long Reach.

448. Where is Long Reach?—That is below Purfleet.

449. Is the water better there?—I think so; the obnoxious stuff, unless it is a very hot summer, has not come into Long Reach yet.

450. That was eight or nine years ago; from that time I understand you to say it has been getting to be as bad as it could be near Gravesend?—If this had been a very hot summer, and there had not been any rain, you would not have been able to bear yourself.

451. You know when the outfalls were opened?—I went by about half an hour after the Prince of Wales had opened the southern one.

452. That was in 1864?—It was in 1864.

453. Have you noticed the state of the banks about Woolwich Reach?—I have not noticed the state of the banks about Woolwich pier, but I have had a vessel lying at Erith, and when there has been no accommodation I have very often slept on shore, and I have then to come down to go on board in the morning before the tide, and the place has been very nearly ankle deep on the shore with the slush which has come out of the sewer.

454. That is at Erith?—Yes.

455. At what part of Erith have you noticed that?—At the causeway.

456. What is the causeway?—A kind of a stone bridgeway.

457. Have you noticed it at all above Erith?—Yes.

458. You know Church Hole, do you not?—Yes.

459. Have you noticed it there?—Yes, I have noticed it upon the shore; but the thing I have particularly noticed it for was not to get ankle deep in it. It must have been upon the shore to have been both below and above the causeway.

460. Do you know the way the tide sweeps round just above Erith?—Where the bights are; it goes into the bights, and it would naturally do so. It comes from Rainham over to the other bight; it sweeps from bight to bight.

461. Let me ask you with regard to the drifting; how far do you consider that sewage put in, say, at high water or a little after high water, at Crossness would get down?—It would, I dare say, extend as far as Gravesend with a spring tide, but with the water that is above and the water that it meets, it would not be so obnoxious as it is in Barking Reach, it is not likely.

462. That is to say, the further it gets down the more the water mixes with it?—Yes; and of course the upper water mixes with it.

463. Upon a spring tide it would get down to Gravesend?—Yes.

464. And upon a neap tide where would it get to?—I would say just below Greenhithe with a neap tide.

465. Then of course it would meet the flood coming back, would it not?—Yes.

466. Could you tell us how far it would be likely to get back on a flood?—I should fancy that it would go nearly up to Greenwich. My idea is that the stuff itself which had gone down the river as sewage had gone down to the bed of the river, but the sewage water itself would come up as far as Greenwich, I should think, or even further.

467. Is the sewage which goes down upon the ebb deposited?—The sediment is deposited in the bed of the river, but the dirty water comes back; and not only that but I have gone down with a tug after I have finished my vessel, and you would see just at high water a large round ball from the outlet right over to the other side and extending a mile, black as ink.

468. (*Chairman.*) You mean a circle?—Yes.

469. (*Mr. Morice.*) What time would that be?—That would be as near high water as possible; for in the summer season we prefer a tug, to coming down by train.

470. In what month have you noticed it worst?—In the month of August and July. If you want to smell it you should leave Gravesend on the tail of the neap tide at 5 or 6 on a summer's morning; it should be a still morning after a fortnight's dry weather. If you then came up the Thames, you would see the largest cesspool in the would.

471. (*Chairman.*) That is leaving with the first of the flood?—About an hour of flood at neap tides. I have many a score of times held my handkerchief to my nose in Halfway Reach and Barking Reach, the smell was so strong.

472. (*Mr. Morice.*) Do you know that some years ago fish used to be caught at that part of the river?—Yes, lots of fish, flounders, whitebait, and shrimps.

473. Where was that?—In Erith and Halfway Reach too; flounders were caught at Erith 40 years ago.

474. How lately could you say that fish have been caught at Erith?—I could hardly say, because I used to go every week up and down the river; but now I have my ship to look after, and that is all I care about.

475. But you remember fish being caught in years gone by?—Yes, I do remember fish being caught 30 years ago at Erith.

Examined by Mr. Webster.

476. You said that before the sewer opened in the year 1864 the state of the river was very bad?—Up in the Pool.

477. What part of the river was bad before the sewer was opened?—From Blackwall up to the House of Commons.

478. Has the upper part of the Pool improved since the outfall was opened?—Very much so. I have slept on board a tug in 1859 in the upper part of the Pool, and I could hardly breathe.

479. But the lower part of the Pool is very bad now?—Yes; we get it now, and the members got it then.

Cross-examined by Mr. Michael.

480. What age are you?—Fifty-three.

481 And you have been 40 years upon the river?—Yes.

482. Do all men who have been upon the river for 40 years present the fine appearance that you do?—Not at all, I am a very steady man.

483. Did you always present the same appearance that you do now?—I do not know that I did; perhaps I have less to do now.

484. However dreadful the water was in the year 1858, which you have described to us, it made admirable tea?—This water which I told you was used for making the tea came from the Thames at half ebb at Blackwall or high water at London Bridge.

485. Did you think at the time that you were drinking diluted sewage?—I do not know. I drank it as a lad would; the water was poured into a cask and the sediment went down to the bottom of the cask and was washed out the next day.

486. You did not think about it?—Not at all; but it was a very splendid river 40 years ago.

487. Now you are thoroughly acquainted with the course of the river, and especially at Erith?—Yes.

488. Do you remember when the dredging took place at two points, one almost exactly opposite Little Cold Harbour, called Great Cold Harbour, and another called Rand's Hill?—Yes.

489. Do you remember the dredging?—Yes.

490. What was the influence when those points were dredged upon the course of the tide?—Upon Rand's Hill I have seen a vessel 6 feet fast; it was so shallow there.

491. At that time I think there was 14 feet of water there?—No; 40 years ago there was not 14 feet of water there; on each side of the hill you might have found it.

492. There is at the present time 14 feet of water?—There is plenty of water there now.

493. But it was 5 feet?—I have seen a Barking smack, which used to go from Barking then and draw about 5 feet of water, fast there.

494. Is it not the fact that before that point was dredged away the tide was obliged to go outside that point and was deflected on to the other side?—(*The witness explained upon the plan.*)

495. Can you tell the Commission, as nearly as possible, what was the time when that point was dredged away?—I do not think it possible that can make any difference to the set of the tide.

496. Never mind the consequence of your answer; I want to know if you can tell the Commission when that event took place?—Nearly the whole of my life have those dredges been at work from Rands Hill to Erith, and from Erith to Rands Hill, and they are now in Long Reach, and it is an extraordinary thing that they should think of making water in Long Reach; I suppose they get better ballast there than anywhere else; but I should think those dredges were between Erith and Rands Hill for 15 years.

497. During the last 15 years have vessels pursued a different course from what they pursued at a period antecedent to that time?—Since 10 years ago they take the middle of the Rand's and do not care about the hill at all.

498. They go over what you say used to have 5 feet of water upon it?—Yes.

499. What influence had the taking away of that point upon the set of the tide?—I do not think it can affect the set of the tide, because the tide must set into the bights, and from bight to bight.

500. But was not it the fact that before that was taken away the tide was deflected round the nose of that point?—It is so now.

501. Before it was taken away, I ask you?—It was not so shoal as all that, but I am referring to the piece of ground in Erith Reach.

502. What was the effect upon the tide of removing the shoal at Rand's Hill?—The tide would run rather faster upon the north side of Rands Hill than it did formerly.

503. Did the tide run harder in this portion that I call the bight, or did it run sharper upon what I would call the northern portion? what was the effect of removing those two points?—I do not know, I could not say. I do not say what effect the removing of a shoal can have unless it is a very bad shoal.

504. But according to your account ships were obliged to go round that shoal, and now ships can go over it?—Yes, that is so.

505. Therefore there was a very much larger quantity of water flowing upon the north side than used to be before?—Yes, no doubt.

506. Would the effect of that be to make more still water upon the southern side?—That I could not say. To us the tide is one thing, we know all the sets of the tide, if we are in a fog we know every inch of the ground, just as a policeman knows every lamp in the street; but as to the effect of the tide running harder in a particular direction since the shoals were taken away you are going beyond me, it is a thing I never thought of.

507. I believe there has been a greater deposit of mud in this portion of the river in the last 10 years than there was before?—There has been.

508. Upon which side?—Upon both sides, in at Erith and in at Rainham Bight.

509. Although there has been a greater flow down the river, that has been accompanied by a greater deposit of mud?—Since the sewers have been opened there is a larger deposit of mud in the lower part of the river than ever was known before, but it is a thing I never studied. Whether the tide has gone harder since they took the two shoals away or not I cannot tell, it took two* years to take them away.

510. But it is quite clear when two years' labour had been expended upon the shoal you were able to take your vessels in the new course?—We had to go up to the south or north of that Rands Hill, either to the north or south.

511. You were obliged to zig-zag the course of your vessel to avoid the shoals?—We were.

512. And now you go over them?—That is so, but

* Subsequently altered by the witness to "twelve" years."

*Mr. J. R. Busby.*

1 Aug. 1882.

whether it affects the set of the tide or not I never thought of.

513. I understand you to say that in the year 1858 the condition of the water was dreadful ?—That was so.

514. How far up did that extend ?—From Woolwich up the river opposite here.

515. That is to say from Woolwich up to the Houses of Parliament, in 1858 and 1859, the river was in a dreadful condition ?—Yes.

516. Having been diluted with a quantity of water in later years it is not so bad ?—No.

517. Now I suppose you are dependent like everyone else upon the amount of tide, as to the time at which you will go up ?—Yes. In the morning, leaving Gravesend at 5 o'clock, if you come up Halfway Reach at about half-past 7 or 8 o'clock, or half-past 6 or 7 and it is as still as a ditch, the stench is something fearful.

518. Is that because by the action of the vessels going up you disturb the bottom of the river ?—The tug ahead of you stirs up the surface of the river.

519. And you have seen this splendid black india rubber balloon preceding you ?—Yes ; only in respect of noticing whether the tide runs any harder since you have removed the shoals I cannot say.

520. (*Chairman.*) What depth of water was there over the Rands Hill 30 years ago ?—About 5 feet of water. I have seen a small vessel ground there.

Re-examined by Mr. Morice.

521. Now you go over it without taking any account of it ; you do not alter your course or consider the tide so far as you have seen ?—No, we do not alter our course at all.

522. As far as you have noticed, the taking away of the shoal has made no difference in the set of the tide ?—I do not think it has.

522*a*. (*Chairman.*) I think the witness said he had not noticed it and was not prepared to say.

523. (*Mr. Morice.*) I think you say, starting from Gravesend you notice the smell more than at any other time after 5 o'clock on a hot summer's morning ?—Yes, 5 o'clock in the month of July or August, or if it is very dry in September.

524. A hot steamy morning ?—Yes ; if everything is still and quiet it is something frightful on those mornings.

525. With regard to the deposit of mud you have told my learned friend that since the sewer has been opened you have noticed the deposit of mud being greater than before ?—Yes.

526. Have you noticed it at all coming down between Erith and the point above Erith ?—Erith, you may say, is the essence of the jelly bag ; they get the worst of it at Erith.

527. That is your opinion ?—Yes.

Examined by the Commission.

528. (*Chairman.*) Mr. Beadle has told us that along the southern shore of the Thames at Erith, the water is slack, do you agree with him ?—It is slacker than it is in the middle ; but still for all that it is slacker upon the north shore than it is upon the south shore.

529. But you said the water ran from bight to bight ?—It is slacker upon the ebb tide close in to Erith than it is upon the north side.

530. But is the water slack upon the southern shore of the Thames opposite Erith ?—Not on the flood, it is slacker than it is in the middle, it stands to reason that the point takes the rush of the tide off.

531. (*Dr. de Chaumont.*) Is the tide any slacker than it used to be ?—I do not think so. I should know if I were going, as I used to be, in the steamers ; but I think something ought to be done owing to the fearful state it is in.

The witness withdrew.

Mr. William Sandford called in, examined by Mr. Morice.

*Mr. W. Sandford.*

532. I believe you reside at Tudor Lodge, Gravesend ?—I do.

533. And you are a shipowner ?—Yes.

534. How long have you known the River Thames ?—For 45 years.

535. I believe you have been a pilot upon the river for a considerable time ?—Yes, for 28 years.

536. (*Chairman.*) Are you a Trinity pilot ? — I was a Trinity pilot.

537. (*Mr. Morice.*) Do you remember the outfalls at Crossness and Barking being opened ?—Yes, I do.

538. Do you remember when that was ?—It is about 15 years ago.

539. About 1864, was it not ?—On or about that time.

540. Could you tell the Commission what was the state of the river between Woolwich and Gravesend before the outfalls were opened ?—It was very bad ; very bad indeed.

541. Where was it bad ?—It did not extend so far as Gravesend, but from Jenningtree Point to Woolwich and Blackwall it was in a fearful state.

542. That was from Jenningtree Point up the river to Blackwall ?—Yes.

543. (*Mr. Bidder.*) Jenningtree is upon the south side off Halfway Reach ?—It forms Halfway Reach.

544. (*Mr. Morice.*) Then I understand that from that point to Blackwall the river was in a bad state ?—And further up, up to London Bridge, *i.e.*, before the outfalls were opened.

545. What was the state of the water down the river from Jenningtree Point to Gravesend ?—They did not feel it at all there before the outfalls were opened.

546. Since the outfalls have been opened have you noticed any difference in the state of the water in the lower portion, viz., from Crossness, where the outfalls are, down the river to Gravesend ?—For the first four or five years after the sewer was opened the water was fairly clear ; it was very good indeed for four or five or six years.

547. Where was it good ?—From Crossness right down to Gravesend ; but since then it has gradually got so bad, and now it is as bad as the upper part was before the sewage was let out at Crossness.

548. Is that in the last few years, or in how many years ?—It has been gradually getting worse the last eight or nine years, not so bad as it is now, but it has been gradually getting worse.

549. I understood you to say it was getting as bad now as the upper part was before the outfalls were opened ?—Yes, that is upon the low water, on the neap tide at low water.

550. That is the time when you consider it to be the worst ?—You feel it more then, the tugs turning their paddles, and the screws their propellers, and the stream being sluggish, stir it up like a black pool ; but coming further up when the stream is stronger you do not notice it so forcibly.

551. What time of the year do you notice it worst ?—Always in the latter part of August, September, and October.

552. And, I suppose, after a run of fine weather ?—Yes ; heavy rains, of course, help you over the outlet a great deal.

553. Have you noticed the mud upon the banks of the river about that part ?—Yes, it is accumulating fast under Crossness ; we used to anchor there in 14 feet and 14 feet 6 inches of water under what we call "Tripcock's" or Tripcock Point ; now you cannot approach it ; you will not find more than 8 or 9 feet at low water in places where you used to find from 4 feet to 14 feet 6 inches.

554. Now you say that from there down, there has been a great deposit of mud of recent years ?—Yes, in the last 8 or 9 or 10 years it gradually got worse ; we got worse water round Maggotness ; it has gradually got worse from the time of the opening of the outfall.

555. Do you know the part of the river from Jenningtree Point, that is the bottom of the Halfway Reach, to Erith ?—Yes.

556. Has there been a greater deposit of mud upon the south shore in recent years ?—Now there is ; there has been more difference there in the last five or six years.

557. (*Mr. Bidder.*) Whereabouts ?—Take it from the "stink factory," as we call it, in Jenningtree Reach. (*The witness pointed out the localities he was referring to upon the plan to the learned counsel.*)

558. (*Chairman.*) You are speaking of the part below Jenningtree Point ?—I am referring to the deposit of mud, not to the factories.

559. (*Mr. Michael.*) I merely mentioned them because the first witness said something that directly affected them, but there are hundreds of factories to be mentioned.

560. (*Witness.*) Why I said the factories was, that below Jenningtree Point, and before you get to the factories there is deep water ; there is one quarter of a mile from Jenningtree Point till you get to the shoal which we call the Sugar Loaf ; there is deep water opposite, the factories, and when you get lower down off Jenningtree Point you come upon an accumulation of mud.

561. (*Mr. Morice.*) From Jenningtree Point round the bend of the river to Erith has there been a deposit of mud greater in recent years than there was formerly ? —Yes, more particularly in the last five or six years ; it is marvellous how it has grown up there.

562. Can you tell us how the set of the tide is down Erith Reach, say from Jenningtree Point ; that is, Erith Reach down to Erith ?—It sets from Jenningtree Point (I am speaking of the ebb tide) below those factories, and then it comes into the curve of the land, and then it takes us straight over to Cold Harbour Point.

563. (*Chairman.*) That is Little Cold Harbour ?—Yes, Little Cold Harbour, where there used to be the old Gravesend boats' channel before the hill was taken away ; we used to go between Rand Hill and this part ; now the rush of the tide and these machines have taken it away.

564. (*Mr. Morice.*) You know there is Cold Harbour Point opposite Erith and Little Cold Harbour just about half way up the Reach ; now which do you mean to refer to ?—The one we call Cold Harbour Point is the one opposite the lower part of Erith. (*The places being pointed out by counsel to the witness upon the plan.*)

565. (*Mr. Morice.*) The witness is referring to Cold Harbour Point.

566. (*Witness.*) The small point we call "False" and there is deep water ; the tide sets over that way towards Erith, and then shoots itself over to the other side towards Cold Harbour.

567. You know what is called Church Hole ?—Yes.

568. From below Church Hole towards Erith, is there any strength of tide ?—There is very little on the ebb tide.

569. What is there upon the flood ?—Upon the first part of the flood you would get a strong tide there.

570. (*Chairman.*) Is it stronger than upon the north side ?—You get it stronger upon the first part of the flood ; but as the water flows, the water distributes itself, and at two-thirds flood there is very little tide indeed.

571. (*Mr. Morice.*) Therefore upon the ebb in coming down would a vessel come into the bight of Erith Bay or would she keep out well in the middle of the river ?—A vessel would not come into Erith Bay. I understand you are referring to a ship drifting.

572. Suppose she is being towed ?—You can tow her where you like.

573. Take a loaded vessel going down the river ?—Letting her alone, having no sail and no propelling power she would not go into Erith Bay.

574. (*Chairman.*) If you were taking her down, as a pilot, would you take her into Erith Bay ?—No, I should take her on to the north shore and then cross over into the bight for Erith ; not into the upper part of Erith, but then you would come into the Erith part in order that you should have the deep set of water over what used to be Rand Hill.

575. Over the deep water between Little Cold Harbour and Cold Harbour Point, and then across to the southern part of Erith ?—Yes.

576. (*Mr. Morice.*) I take it that in Erith Bay round by Church Hole, if you were taking a vessel down you would take her in the middle of the stream and make towards the northern part ?—Church Hole is a deep hole, it lies with the church upon the west by south ; we take the deep water and sweep round Cold Harbour proper, but we do not come so high up as Church Hole.

577. In that part of the bay that you would not go into, is not there slack water ?—Yes, truly ; that is why the mud curls up, it is the counter tide that causes that settlement to stir up ; we have one hour difference of tide from Gravesend to London ; now you can go to Yarmouth, that is, outside Yarmouth sands, where there is only one hour's difference between Yarmouth and the Nore, that is 110 miles where you have only one hour's difference, and you have an hour between Gravesend and London ; so that although your tide appears to be running out yet your under current is running up. I have proved that by throwing a basket overboard with ballast in it and sinking it, and the basket will propel the boat against the stream.

578. There is a counter current in Erith Bay ; is that what we are to understand ?—Yes, that is so.

579. Are we to understand that that is not upon the surface but a little above the bottom when you spoke of sinking a basket ?—The basket would be sunk within a foot of the bottom.

580. Does that current appear upon the surface ?—No.

581. How far below the surface would you have to sink the basket before you would meet the counter current ?—Within 4 or 5 feet of the bottom ; it does not come all at once, but you begin to perceive it when it is within 6 or 7 feet of the bottom, but more particularly within one foot.

582. That is during the last ebb ?—During the last quarter ebb.

583. And only during the last quarter ebb ?—Yes.

584. How fast would you say the current runs up against the tide ?—There is not much current, you might say a quarter of a knot.

585. At the last part of the ebb in Erith Bay which we have been talking of, is not there a young flood making up at the last part of the ebb ?—Yes, that is the very thing I have been talking about ; there is a lot of stuff deposited from the factory and that under-current curls it up.

586. What do you mean by the "factory" ?—I mean the outlet at Crossness.

587. (*Chairman.*) Are we to understand from you that this under current is the young flood creeping up ; is that your opinion ?—It is my opinion because I have proved it.

588. Then what you tell us is this, that this set upwards is the young flood creeping up under the last of of the ebb ?—Yes.

589. Does that go on increasing ?—Directly the flood is made then that ceases, but it ceases gradually.

590. (*Mr. Morice.*) You know the river well as you have just been telling us about the state of the tide. Now if sewerage matter were put in at high water upon the spring tide, how far would it get down upon the ebb below Crossness ?—I do not believe it would reach further than Purfleet, but taking it that it might reach a little further, at all events it would not go mech further, say, to Greenhithe ; for instance, you

*Mr. W. Sandford.*
1 Aug. 1882.

never pick up a body that is drowned about Crossness below Purfleet; should a man drown in Half-way Reach or anywhere there, the body may reach Purfleet, but I never remember it being found below Purfleet.

591. (*Mr. Michael.*) At spring tide?—At spring tide you might find it a little further out, but very little.

592. (*Mr. Morice.*) On the neaps how far would it get down?—A very little way, it might get to Erith perhaps.

593. Have you ever suffered any illness from the state of the water yourself?—I could not say that I have felt that, I may be glad to get a mouthful of air and that sort of thing.

594. You feel a sort of choking sensation?—Yes.

595. Do you remember when there was fish in the river?—Yes, I do, but I should like to say this, that we used to make our best effort to watch the time to get clear of the stench, we would lose an hour to clear the stench.

596. Now I was asking you do you remember fish in the Thames between Woolwich and Gravesend?—Forty-five years ago I brought a voyage of fish from Iceland in the well, alive; we lay four days at Gravesend, and we used to send eight or ten score up to market every day, then we moved from Gravesend to Greenwich.

597. (*Chairman.*) You kept them alive in the well?—Yes, the ship was so constructed that we could keep the fish alive in the well.

598. What is the longest time you have kept fish alive in the well?—Eight or nine weeks, we used to keep them alive during the voyage.

599. How long have you lain at Gravesend with the fish alive?—I have lain there a fortnight.

600. Did you keep the fish alive and in good health?—Yes, you might pick out two or three dead; we used to have a staff to pick them out, but still they would not be very numerous. Then we would go to Greenwich, and market the rest from Greenwich.

601. (*Mr. Morice.*) How many years ago, taking the most recent case, have you brought fish up the river to Greenwich?—It is 38 years ago since I had any fish.

602. Do you remember when fish was caught in the river itself?—Yes, for the best of good reasons, that my mother had several of these vessels.

603. How long ago is it since fish were caught in the river up at this part?—Up to about 12 or 14 years ago they were caught.

604. Whereabouts would that have been specially?—The whitebait was caught at Blackwall.

605. Up to what time can you tell us?—No, I feel a little adrift in dates; when you talk about the sewer having been open obout 15 years it makes me begin to think; but 25 years ago I have caught salmon and sturgeon too, below Woolwich.

606. (*Mr. Michael.*) How many?—It was a common thing to do to catch salmon and sturgeon there.

607. Every season?—Yes, every season; the sturgeon lasted longer. Even now it is common for them to catch sturgeon, but it is down towards Hole Haven and towards the Nore.

608. (*Mr. Morice.*) How far down now since the outfall has been opened are fish caught?—You cannot stop at Gravesend with live fish.

609. Not in a well?—No, you could not keep them alive, they would die.

610. Why?—Because of the pollution of the water; the water is so bad.

611. Do you know the state of the mud on the banks on the lower part between Woolwich and Gravesend?—I do not see that there is much difference in it; it may be darker, but I could not say much about that; I have not been ashore to prove it. I have to do with the water and with the navigable part of the river.

Cross-examined by Mr. Bidder.

612. As I understand the mud that produces the offensive smell has been accumulating in the parts you have indicated of late years?—Yes.

613. And that is what has made it so much worse?—Yes.

614. It used to be deep water there?—Yes.

615. Now you have instead of deep water and a clean bottom an accumulation of mud?—Yes, quite so.

616. That is what accounts for the change you have described?—Quite so.

617. The Thames mud, as we know, has always been a very offensive stuff?—Yes, it has, for the last 35 years.

618. Now, about the fish; you said you could not keep live fish now in a well at Gravesend; have you ever tried it?—No.

619. Did you ever know anybody who had tried it and failed?—I know that our fishing boats belonging to Gravesend, if they get fish, sweep them out before they come to Gravesend to save their lives.

620. Do not some of the boats come up to Billingsgate with fish in the well?—No.

621. None of them?—I do not think so. I am not sure whether some of the eel men do or do not; it is possible some of the eel men may, but I think not.

622. Now with regard to the salmon and trout, you have awakened my interest in a way that I hardly expected?—I spoke of salmon and sturgeon.

623. Where were they caught?—They were caught in Long Reach.

624. When was the last salmon caught in Long Reach as a matter of curiosity?—It is a good while ago since the last salmon was caught in Long Reach, but last summer there was one caught between the Nore and Gravesend.

625. In the nets?—Yes, but it was not an uncommon thing to catch salmon in Long Reach; I am speaking now of 20 years ago, and not at all an uncommon thing to catch sturgeon.

626. You said that sewage put in at high water at Barking or Crossness would not reach Purfleet?—I think not, at any rate not lower than Greenhithe.

627. Have you ever tried that experiment—you mean on one tide?—I mean on one tide.

628. You have not tried the experiment?—I have not.

629. It is a mere general opinion?—It is nothing more than my opinion.

630. Now how about the smell. There are a great number of villainous smells along both sides of the river, are there not?—There are smells from factories that are offensive when you get high up.

631. Have you ever tried the smell of the fish manure factory?—I have not noticed that. I have noticed the factories higher up, at Blackwall.

632. When was the last occasion when you noticed any smell from the river?—It is five or six weeks ago.

633. Where was that particularly?—That was from Erith, and from Jenningtree Point up to Crossness, and as bad as we get along. I did not see much difference.

634. You smelt it from Jenningtree to Crossness?—Yes. I went up in my own tug for pleasure, and I remarked "This is coming it rather stiff. I will not "go again."

635. Was that high water or low water?—Low water.

636. It was between those points you first noticed it?—Yes, that was the first time I noticed it; but afterwards I noticed it all the way.

637. I wish to know between what points you noticed the smell?—It began at Jenningtree Point and continued.

638. It was worse when you got to Crossness?—It was worse when I got to Crossness, but it was not nice all the way.

639. You may put it between those points?—I would not distinctly confine it to between those points

I could not say "it is sweet here and sour there," but it might be a little better at the beginning than it was at Crossness. It was at Jenningtree Point that I first smelt it. It was very bad when we got to Crossness, and it was not quite so bad afterwards, but I do not say it stopped; it does not stop all at once.

640. How far would you say it extended up perceptibly?—I do not know. I only know this, that it was very bad there, and I smelt it all the way up.

641. That is five or six weeks ago. Can you refer to any other occasion when from personal observation you have noticed the smell?—No.

642. That is the only occasion upon which you observed it?—No, certainly not. Always when I have navigated the Thames I have smelt it.

643. You did not quite hear the whole of my question. Can you refer me to any other occasion upon which you personally have observed an offensive smell?—Upon all occasions when I have navigated the river during the last quarter ebb.

644. Between the same points?—Yes.

Re-examined by Mr. Morice.

645. I understand you have not been going upon these occasions that you have been asked about, specially to smell or to ascertain the stink?—Certainly not.

646. Whenever you have been in the neighbourhood you have smelt the stink?—Yes.

647. And that extends more or less all the way up?—Just so.

The witness withdrew.*

* The witness subsequently added to his evidence the following note:—
"I recommend that the sewage be carried to the east shore of the Lower Hope below Gravesend, on the south side, so that the inlets at Cliffe would push it over to Mucking, from whence numerous outlets on both sides would carry it out to sea."

Captain Arthur Morrel, R.N., called in, examined by Mr. Morice.



648. I believe you are the captain of the "Cornwall" training ship?—I am.

649. You are in the Royal Navy?—Yes.

650. I believe you have been in the "Cornwall" for the last nine years?—Yes, for nearly nine years.

651. What part of the river is she lying in?—At Purfleet.

652. How long have you known the River Thames?—I have known the River Thames for 20 years and upwards, off and on.

653. Do you remember when the outfalls were opened at Crossness and Barking?—No, I was abroad at the time.

654. Do you remember the state of the river before that time?—Yes, I remember the state of the river very well.

655. Was the water used at all for drinking purposes before then?—Yes, about that time water used to be used for drinking from the Thames.

656. About what time?—About 20 odd years ago.

657. Before the time you are speaking of, what opportunity had you of knowing the river then?—I was residing at Erith, and used to go down with a bathing party sometimes of a morning, and a tolerably good bath one had in those days.

658. That is about 20 years ago?—Yes.

659. Is there any difference, as far as you have noticed, in the state of the river of recent years?—A very material difference.

660. In what way?—I consider it very much impurer.

661. To what do you attribute that?—It would be rather difficult for me to say. To impurities which are being emptied into it; that is what I should say.

662. Do you use the water of the river for any purposes on board the "Cornwall"?—Very seldom.

663. Used you to use it some years ago?—Yes, for washing the decks and for the boys bathing sometimes.

664. Have you altered that practice for any reason?—I have discontinued it for several years.

665. On what grounds?—Because it used to smell so bad that it was unhealthy.

666. What kind of a smell was it?—A sickening smell, arising from gases, it seemed to me.

667. Anything like a sewage smell?—I can hardly tell you that, for I have not been much in the vicinity of sewage.

668. At any rate you have given it up for the purpose of washing the decks and for bathing?—We very seldom use it for washing the decks; sometimes we might use it at the top of high water for the purpose of washing the upper deck, but never between decks, but just so as to save fresh water.

669. You have to use fresh water for the purpose of the decks and bathing?—Yes.

670. Where do you get the fresh water from?—From the Grays Waterworks.

671. Have you had any illness on board the "Cornwall"?—I had a very severe epidemic of typhoid in 1875–76.

672. Did that have any effect in inducing you to discontinue the use of the Thames water in the "Cornwall" at all?—That was one of the reasons which induced us to discontinue it, because we had two very eminent medical men from London to ascertain what had been the cause of the fever, and as they were unable to clearly discover it, we at all events thought we would discontinue the use of the water.

673. Since the time you left off using the Thames water have you had as much sickness on board as you had in previous years?—Certainly not.

674. (*Chairman.*) Have you had the same number of boys all along?—Very nearly; we vary. We have from 200 to 250.

675. (*Mr. Morice.*) Taking the percentage the amount of illness has been less since?—It has.

676. Can you tell us how much less it has been in figures?—I can hardly tell you in figures.

677. Can you not give it approximately?—We had two or three severe epidemics some years ago. We have had no epidemics for the last four or five years, although we have had one or two individual cases; in fact we had 10 or 12 cases three or four years ago.

678. Did those epidemics follow rapidly one after the other?—We had one in 1875 and 1876, and again in the following year and then afterwards, but not to so large an extent.

679. That would mean 1875, 1876, 1877, and 1878?—Yes, in 1877 and 1878 we had touches of fever; isolated cases.

680. (*Dr. Stevenson.*) And you have had 10 or 12 cases since then?—Yes, we have had 10 or 12 cases since then.

681. But you have had no really serious epidemic?—No, we have had no really serious epidemic; the water had not been entirely discontinued then. I have discontinued it the last three years entirely, but we used at first to leave it off here and there.

682. (*Dr. Chaumont.*) Have you had any cases since you have entirely discontinued the use of the water?—We have had isolated cases, presumably from a boy having touched the water, or tasted it, in cleaning out the boat or on shore.

683. Since you left off the use of the water have you not had a case of typhoid?—No, not since we left it off altogether.

684. (*Dr. Stevenson.*) So the 10 or 12 cases you referred to were not cases of typhoid?—We had 10 or 12 cases of typhoid about four years ago.

685. (*Mr. Morice.*) Do you feel any effect from the water?—Getting up in the morning I feel a sickness which I have been unable to account for. I presume there must be some cause for it, and I attribute it to the water.

*Capt. A. Morrel, R.N.*

1 Aug. 1882.

686. Do you know whether the smell of the water has been getting worse in recent years?—I should say it has been getting gradually worse every year.

687. Have you noticed the mud deposits upon the banks?—I have not had much opportunity of doing that, for I have much office work and I am very much shut up in my office on board.

Cross-examined by Mr. BIDDER.

688. Of course you are not a medical man?—I am not.

689. But you have, I presume, a medical officer on board the "Cornwall"?—We have one who visits every day or nearly every day.

690. Is that Mr. Netten Radcliffe?—No; he visited me two or three times.

691. What is Mr. Netten Radcliffe, is he a medical inspector of the Local Government Board?—I really do not know, he visited me two or three times.

692. Do you remember that after these epidemics you have mentioned Mr. Netten Radcliffe was sent down to inspect the "Cornwall" and to make a report as to the health of the boys?—Yes, I remember that very well.

693. Let me call your attention to the memorandum of Mr. Netten Ratcliffe on the reformatory school ship "Cornwall" addressed to Mr. Edward C. Seaton, M.D., Medical Department, and dated June 4th, 1878. I see he was directed by the Local Government Board to make an inquiry, first into the sanitary condition of the reformatory school ship "Cornwall" especially with reference to the recent prevalence of enteric fever among the boys, and secondly "into a suggestion "that the health of the boys probably suffered from "the outflow of metropolitan sewage into the river, "higher up the stream, at Crossness and Barking," do you recollect that he came down to make inquiries into these subjects?—I recollect his visits very well.

694. I will not read the memorandum at length, but I will ask you this, were you the captain superintendent at the time?—Yes, I was.

695. Let us see if you can confirm what he says here as this statement appears to be made with your authority. "But it is proper that I should offer some "observations on the opinion entertained by the "captain superintendent and others on the general "state of health of the boys. The captain superin-"tendent lives with his family on board the ship, and "has the boys constantly under observation. He "states that, except when infectious disease is intro-"duced among the boys from the shore by new "comers, there is great freedom from serious sickness, "and that even minor ailments are rarely trouble-"some"?—Yes, he is speaking of 1878.*

696. He is speaking in 1878, and I may take it he correctly reported your own observation and experience at the time, because he says he had it from the captain superintendent, that is yourself?—Yes.

697. That was correct at the time, was it?—I do not recollect at all what I said to Mr. Netten Radcliffe.

698. I suppose Mr. Netten Radcliffe would not be likely to have imagined that. Was it in accordance with your observations that there was great freedom from serious sickness "except when infectious disease is in-"troduced among the boys from the shore by new "comers"?—No, we very seldom do have any disease introduced by new comers, except itch or something of the kind.

699. But it is very strange that he should have said that if you had not told it him?—I do not recollect telling him anything of the kind.

700. Now is it correct to say that "minor ailments "are rarely troublesome"?—We have very little sick-ness as a rule.

701. He says upon the same page. "Thus from "the 22nd August 1876 to the month of May 1877 "there appears a succession of entries of 'sore throat,' "and 'tonsillitis,' in all 62 in number. In December "1876 scarlet fever appeared amongst the boys. "Fourteen cases of this disease, five cases of enteric "fever were sent from the ship to the Seaman's "Hospital, Greenwich during this month"?—And they all came back again with nothing the matter with them, all except three, I think.

702. That is very satisfactory. Now he goes into a good deal of statistics, and the desirability of more accurate records, and here I come to his conclusions. "With reference to the prevalence of enteric fever "among the boys in the 'Cornwall,' the inquiry had "particularly in view an examination of the circum-"stances under which a considerable outbreak had "occurred, beginning in September 1875 and ending in "January 1876. The state of the medical register, "and the absence of the medical officer who had charge "of the ship at the time, presented an insuperable "obstacle to my obtaining the details of the outbreak. "An investigation of it had, however, been made by the "medical officer of health for the port of London, Dr. "Harry Leach, during its progress," do you happen to remember that investigation?—I remember having several visits from Dr. Leach.

703. "The results of that investigation, as given in "his report for the half-year ending the 31st Decem-"ber 1875, contain the only account of the circum-"stances of the outbreak now likely to be obtained. "I have had several conferences with Dr. Leach on "the subject, and I concur with him in his con-"clusions and recommendations. The latter have "been substantially carried into effect by the school-"ship committee, and need not be further referred to "here. As to the origin of this outbreak of enteric "fever, I am of opinion, as the result of my own in-"quiries, that the disease was introduced into the ship "from the shore." Were you aware that that was the conclusion which the medical gentleman who inquired into the case arrived at?—I do not know that he came to any conclusion.

704. Did you never see this report before?—I do not think I did.

705. Did you never take sufficient interest to induce you to procure it?—I took, on the contrary, great interest in it.

706. I will read you a little more, because this will be news to you. "It may be accepted also, I think, "that a like origin is to be assigned to the several "prevalences of infectious diseases, including enteric "fever, which have occurred amongst the boys from "time to time. Under the present arrangements of "the ship boys are sent directly on board from the "original places of detention, without a precautionary "delay of sufficient duration to enable it to be ascer-"tained whether they may be in the incubative "stage of certain of the infectious diseases. Hence "the ship is at all times liable to have introduced "into it children sickening or about to sicken from "enteric fever, small pox, &c. Again, the ship has "no proper provision for the immediate isolation of "cases of infectious sickness, or of doubtful cases as "they occur. Such separation as can be effected on "board is futile for the purposes of isolation." Then he recommends quarantine and a place on shore. Next, he says, "The suggestion that the health of the "boys on board the 'Cornwall' may suffer from the "outflow of metropolitan sewage into the Thames at "Crossness and Barking appears to have arisen from "a conjecture that the recent prevalence of enteric "fever among them possibly had some connexion "with the pollution of the stream from this source. "I have already expressed the opinion that in the "outbreak of 1875–76 the disease was introduced "among the boys from the shore, and that the "malady, in the first instance, has at other times "been imported into the ship. Unable, from the "condition of the medical register, to approach the "question, as will be necessary before it can be com-"pletely solved, from a clear knowledge of the kinds "of sickness most apt to affect the boys, I have

* The witness, in correcting his evidence, denies having made the statement in the last part of this question.

" endeavoured to ascertain whether the condition of " the river at the point where the 'Cornwall' lies, " with reference to the flow of metropolitan sewage, " was such as to lead to the inference that the ship " was moored in an unwholesome position. I have " already stated that the 'Cornwall' lies off Purfleet." Then he describes the kind of ship, which I need not read. She "is moored close to the shore, 7 miles " below the metropolitan sewage outfall at Barking, " and 5½ miles below the sewage outfall at Crossness. " On the 18th August 1877, in company with Dr. " Harry Leach, I witnessed from the river the flow " of sewage into the stream. The day was peculiarly " favourable for observation. The surface of the " water was hardly disturbed, and then only at in- " tervals, by a gentle current of air from west-south- " west, so that it was practicable to follow the move- " ment of the sewage at the surface with the greatest " precision. It was about two hours of ebb tide when " we reached the Barking outfall. Sewage was " flowing thence in a broad, black, offensive stream, " carrying much floating nastiness on the surface. " The sewage hugged the near bank of the river until " it reached the mouth of Barking Creek, when it " was deflected towards the centre of the stream, " spreading out fanlike at the same time. The sewage " then flowed along mid stream, the current rapidly " breaking up and becoming dispersed, and a mile " below the outfall, opposite the powder magazine " just above the Crossness point, it was entirely lost " to sight, not even a trace of the floating matter " being discoverable, although several casts backwards " and foward across the river at this part of its course " were made in search of it. On approaching the " Crossness outfall three-quarters of a mile below the " point, where all trace of the sewage from the " northern outfall was lost to the sight, the odour of " sewage met the nostrils in advance, and the southern " sewage stream carried upwards in part by an eddy, " was entered a little above the outfall. The sewage " had the same aspect as that from the northern out- " fall. It hugged the southern bank in a broad well " defined current for three-quarters of a mile, then, " opposite the Belvidere Guano Works, it broke up " into several branches and spread out towards mid- " river, and a quarter of a mile below, opposite the " powder magazine there, all traces of sewage were " lost to sight." Does that agree with your own obser- vation, or have you anything to say to the contrary?—That is not at all my observation; those are Dr. Netten Radcliffe's observations, I think. I was not present, and do not know anything about them.

707. Then the memorandum goes on "On a sub- " sequent occasion (13th Oct. 1877), with the object " of ascertaining, if this were practicable, whether " the bed of the river where the 'Cornwall' is moored " was affected by the metropolitan sewage outflow I " collected specimens of mud from the bed of the " river inshore off the Barking and Crossness out- " falls, from beneath the 'Cornwall,' and from the " mud exposed at low water on the contiguous bank, " and from the bed of the river at Greenhithe at a " point between the 'Arethusa' and 'Chichester' " school ships lying there and the bank, seven miles " and a half below the Crossness outfall. For the " purpose of collecting these specimens the secretary " of the Thames Conservancy Board, Captain Burstall, " R.N., courteously put at my service the conservancy " steam yacht, and Captain James, the harbour " master, gave me his valuable assistance. The " specimens of mud collected off the Barking and " Crossness outfalls (that from Crossness being taken " from several points on an exploration rod, which " had been sunk over 10 feet into the mud bank, from " which mud was collected), and from beneath the " 'Cornwall' had the appearance and odour of " ordinary sewage mud. The specimen at Greentithe " had the appearance and odour of common river " mud as observed anywhere within the tidal stream. " These specimens were submitted to Dr. Dupré for " chemical analysis, and he added to them for addi- " tional comparison specimens of mud taken at low " water from the bank of the Thames at Vauxhall " Bridge and adjoining the Houses of Parliament. I " append Dr. Dupré's report of the result of his " analysis. It will be observed in this report that, " with one exception, chemical analysis failed to show " any material difference between the several " examples. 'They all consisted,' to use Dr. Dupré's " words, 'chiefly of sand, clay, and chalk, and con- " 'tained only a small proportion of organic matter. " 'This organic matter, moreover, seemed to be very " 'much of the same character in all, as shown by " 'the slight variations in the relative proportion of " 'carbon and nitrogen present in it. In fact only one " 'sample (No. IV., the sample taken from beneath " 'the 'Cornwall'), shows any material departure " 'from the mean in this respect. In this the pro- " 'portion of carbon to nitrogen is very much greater " 'than in the rest, showing the organic matter in it " 'to be of vegetable origin chiefly. This is due, no " 'doubt, to the admixture with it of an exceptionally " 'large proportion of disintegrated wood. In samples " 'I., II., and VII. (the first taken from the bed of the " 'river opposite the northern outfall, the second " 'taken from the mud bank, opposite the Crossness " 'outfall, and the third from the mud bank 50 yards " 'below Vauxhall Bridge, on the Surrey side), the " 'proportion of carbon is slightly below the average, " 'which may be taken as indicating a somewhat " 'higher proportion of animal contamination, due, " 'perhaps, to the presence in these samples of a " 'larger proportion of sewage deposit. As before " 'stated, however, neither the chemical nor the " 'microscopic examination lends much countenance " 'to the supposition that one sample consists more " 'than another of sewage deposit.'" Now, have you any observations or anything to contradict that?—With regard to the boys, in the first place, they are committed by the magistrates for sometimes three weeks or six weeks or more, generally a month before they come to us, so that they have not an opportunity of bringing anything into the ship.

708. They may catch it in gaol?—They have certi- ficates with them, and I have them examined.

709. Is that by the medical officer of the ship?—Certificates by the medical officer of the gaol, certi- fying that the boy has passed the examination, and is in good health.

710. But nobody can detect the infection in the earlier stages of incubation?—Not a single boy has had an infectious disease within a short time after his coming on board; we have never had a boy who has really produced an illness in the ship.

711. Mr. Netten Radcliffe comes to a directly con- trary opinion?—He cannot know so much about it as I can, or as my books will show.

712. I suppose you gave him all the information he required?—Certainly; he asked a great many ques- tions, and I gave him all the information within my power.

713. Next let me draw your attention to this. He says, "It is to be inferred either that the suspended " matters of the sewage which finds its way into the " Thames both above the metropolitan area towards " the source of the river, and below the metropolitan " area at Barking and Crossness, are equally dis- " tributed within the section of the river selected for " examination, or that each successive outflow of " sewage at the Barking and Crossness outfalls under- " goes so great a dilution and dispersion as practically " to become unrecognisable on the cessation of the " flow from any deposit of suspended matter it con- " tained. In either case sewage matter in solution " may be regarded as an almost inappreciable quantity " and ignored accordingly. It is not necessary for " the purpose of this inquiry to determine which of " these alternatives is the most probable. If the " former, there is no evidence to show that the posi- " tion of the 'Cornwall' off Purfleet is more unhealthy " than the position of any of the other school ships " on the Thames, and it is not known that the health " of the boys of any of the ships has suffered from " the position in which the different ships are moored;

*Capt. A. Morrel, R.N.*

1 Aug. 1882.

"if the latter, there is no evidence that the boys on "the 'Cornwall' are likely to be exposed to any "injurious influence from the outflow of the metro- "politan sewage at Barking and Crossness." Then I see he says this, and as you have said something about smells I will read it. "In the course of the "inquiry it was stated to me that at times much "disengagement of fœtid gas from the water about "the 'Cornwall' had been observed, particularly "when at very low tides the keel had happened to "touch the mud beneath her. I failed to get any precise "evidence as to this statement, but the phenomenon "has not been noticed during the time the present "captain superintendent has had charge of the ship;" is that correct?—I must say I have not smelt very much.

714. Indeed at the present time very little mud indeed lies beneath the ship, the greater part of the area of the river bed underneath being free from deposit.

715. (*Dr. de Chaumont.*) How soon after arrival on board ship has any boy ever been taken seriously ill, say with typhoid fever?—I do not remember any boy being attacked with typhoid fever who has lately come into the ship. I do not think the origin of it was brought from the shore.

716. Could you say at all the shortest time that any boy had been on board before having such an illness?—I could not at the moment, but I could furnish the statistics of it, because I have the particulars of the time of entry, and where they sleep, the nature of the illness, and so on.

717. Would they have been on board the ship any time before the illness?—Yes, some months.

718. (*Dr. Stevenson.*) Could we be furnished with Dr. Harry Leach's report?

719. (*Mr. L. Smith.*) He was medical officer of the city, and I have no doubt we can procure it.

720. (*Chairman.*) You spoke of having resided at Erith?—Some 20 years ago I used to go there off and on, my father was living there.

721. What length of time have you been there?—A month or six weeks at a time perhaps on coming home from abroad, or from Ireland, or from where I have been stationed.

722. And that extended over a period of some years?—Yes.

Re-examined by Mr. Morice.

723. Have you seen the report which has been read before?—I think I did when it came out, or read some parts of it, I think.

724. I understood you to say that you cannot agree with what it states there as regards the cause of the outbreak?—I do not think anybody knows really the cause of the outbreak. I do not think it ever was or could be clearly proved.

The witness withdrew.

Captain Frederick Walter, R.N., called, examined by Mr. Morice.

*Capt. F. Walter, R.N.*

725. I think you belong to the Royal Navy, and are in the "Arethusa"?—Yes.

726. I think you have been in the "Arethusa" for eight years?—Yes, since November 1874.

727. Where is the "Arethusa" stationed?—Off Greenhithe.

728. That is at the end of Long Reach?—Yes, between Long Reach and Fiddlers' Reach.

729. How long have you been acquainted with the river Thames?—Since that date.

730. Can you tell us during those eight years whether there has been any alteration in the state of the river to your knowledge?—Yes.

731. Has it been getting better or worse?—In my opinion it is worse.

732. During the last three or four years has it been very much worse or otherwise?—Worse, I think.

733. You say the river has been getting worse, do you remember when the fishing boats used to come up to Greenhithe?—Very well.

734. How long ago was that?—Four years; the last boat I think was three or four years ago.

735. (*Chairman.*) When you say fishing boats do you mean they used to fish there, or that they used to come up the river?—They used to fish there; in the autumn we used to have as many as from 15 to 20 boats catching shrimps and dabs.

736. (*Mr. Morice.*) Since that time have you seen any?—Four years ago there were about two, and since that time there have not been any.

737. Have you had any illness on board the "Arethusa" since it has been there?—Yes, we have had some.

738. Have you ever had any fevers?—We had typhoid fever between 1879 and 1880, not since then.

739. Have you been in the habit of using the Thames water for any purpose on board the ship?—We use it at present for washing the upper deck.

740. Used you to use it to any greater extent?—We used at one time to use it for all decks, until fever broke out in 1879.

741. And since the fever broke out in 1879 what have you done?—We discontinued using it from that time upon the lower deck, which was the sleeping deck.

742. May I ask for what reason you gave up using the water so much?—We were anxious to find out the cause of the fever, and as it struck me that using the water upon the lower deck would probably cause sickness, among other precautions, I discontinued it.

743. Was the water that you were using pure water?—No, decidedly not.

744. What then was the reason for your giving it up?—It was very dirty, and also if it remained upon the deck a short time it smelt very badly.

745. And therefore you gave up using it upon the deck where the boys slept?—Yes.

746. When do you find the water in the river is the worst; at what time of the year and of the tide?—In the hot part of the year certainly it is the worst.

747. And do you notice any smell from it?—Certainly, in hot weather and at low tide.

748. I believe you lie pretty close to the shore at Greenhithe; do you notice the mud on the banks at all?—We see it.

749. Has there been any greater deposit there of the mud lately, in the last few years?—I cannot say that.

750. Have you noticed the colour of it or the state of it?—I do not notice any alteration in the colour.

751. During the eight years that you have been there have you not noticed any alteration in the colour?—No.

752. (*Chairman.*) How far does your ship lie from low-water edge?—From low-water edge it lies about 80 yards.

753. (*Mr. Morice.*) How do you land at Greenhithe; is there a pier or a causeway?—A wooden causeway.

754. (*Dr. Williamson.*) Is the water clean enough for boys to bathe in at your ship?—We bathe at the top of high water only; at low water it is too dirty. I do not let them bathe except at the last quarter of the flood or the first quarter of the ebb, so as to get the water at its freshest.

755. (*Mr. Morice.*) Is that a recent alteration which you have made?—No, I have always done that.

Cross-examined by Mr. Michael.

756. If I rightly understand it is at low water that you smell something bad?—It is not only at low-water but it is principally at low water.

757. How much of the mud is exposed at that time?—That is a matter of opinion; I should say 150 yards, but I do not know exactly.

758. Do you know what the characteristics of Thames mud are in respect to smell?—They are very bad.

759. Do you know that it smells worse than any other mud?—I know it has a very bad smell.

760. Do you know whether it is the water or the mud of which that peculiar sweetness is the special characteristic?—I have not discovered any sweetness about it, but I should say that the mud is the worst.

761. How do you discover that?—If I go out upon the stern walk when the water is stationary I smell it more than if it is running.

762. I will ask you this. Does not it suggest itself to your mind that if the water is very impure, and it is stirred up, you would be more likely to recognise the impurity by the smell than if it were perfectly still?—I do not think it follows if there were any breeze blowing.

763. But a breeze would ruffle the water?—It would take the smell away from the ship.

764. Not if it were blowing towards the ship?—It must be blowing away from the ship in one direction.

765. And also by parity of reasoning it must from one direction be blown across the ship. Now what is the general health of the boys?—Very good.

766. What is the number of boys on board?—313.

767. What is the mortality among the boys?—I do not remember exactly, but I keep a record. Last year we lost two. This year so far we have lost none.

768. At what age do they enter?—From 13 to 17, and they go up to 19.

769. What is the average?—15 years.

770. What did the two boys die of?—One died of consumption; they both died in hospital. As a matter of fact, we did not keep them on board.

771. What did the other one die of?—He died from some affection of the lungs.

772. Do you think that was occasioned by the quality of the water or the smell?—No, I should not say that.

773. The last year before that how many were there died?—Two.

774. Have you had any cases of scarlet fever?—No.

775. Or diphtheria?—No.

776. Have you had any cases of enteric fever?—That I believe is something like typhoid.

777. Yes, typhoid fever. How many cases have you had of that?—We did have an epidemic of that three years ago. We had 17 cases, and before that we only had isolated cases.

778. Over what period did the 17 cases range?—Nine months.

*Capt. F. Walter, R.N.*

1 Aug. 1882.

779. (*Chairman.*) How long ago was that?—It broke out in 1879, and the last case was in the summer of 1880.

780. (*Mr. Michael.*) What step did you take with regard to them?—We sent those who were ill to the hospital.

781. Did you take any steps to discover whether there was any special cause for the breaking out of typhoid fever?—We took every step to examine into the origin of the outbreak.

782. With what result?—We never discovered what it was.

783. What has been the condition of the water since?—I have not noticed anything different.

784. What sort of health do you personally enjoy?—Very good.

785. Is it principally during the warm weather that you noticed the smell?—Yes, in the hot weather.

786. The river bank is exposed at that part of the tide in the summer to the heat of the sun?—Yes, but it smells both at high and low tide.

787. Have you had any experience of the mud of the Thames in hot weather at any other part of it than where the ship is lying?—No.

788. Or any other river?—Yes, I have lain in other rivers.

789. What others?—The Canton river.

790. That is not a very sweet smelling river is it, or the mud from it peculiarly salubrious?—Hardly so.

791. Can you say whether you would like to be anchored during the whole of the year upon the mud of the Canton river?—I cannot say that I should like it.

792. What do you think would be likely to be the effect upon the health of 300 boys of being anchored for a year upon the mud of the Canton river?—Leaving other things out of the question, I do not think that they would be worse than being in England.

793. Leaving what other things out of the question?—The climate generally.

Re-examined by Mr. Morice.

794. I understand you to say however that in the last two or three years you have not had much illness, as you have discontinued using the water upon the lower deck?—Yes.

795. The outbreak of the fever was when you were using the water upon the lower deck?—We discontinued it when the fever broke out.

796. Since that time you have had no cases?—We have had no cases since that outbreak ceased, and that lasted over about nine months.

797. That was in the summer of 1880?—Yes.

The witness withdrew.

Captain Arthur Gillett, R.N., called in, examined by Mr. Morice.

798. You belong to the training ship "Warspite"?—I do.

*Capt. A. Gillett, R.N.*

799. Lying off Woolwich?—Yes.

800. How long have you been in the "Warspite"?—Nearly five years.

801. During that five years have you noticed the state of the water in the river?—Yes.

802. Can you tell us whether it has been altering either for the better or worse?—I do not think it has varied.

803. Have you noticed as to whether the water is in a pure or an impure state off your ship?—Just now it is very clear.

804. During the last two or three years can you tell us what has been the condition of it?—For a month in the middle of the summer, generally in July, it has been very bad; the water becomes slate-coloured, and great masses of black mud come up from the bottom and spread all over the surface.

805. (*Chairman.*) Has that been so this summer?—No, not this summer yet.

806. (*Mr. Morice.*) But the last two or three years has it?—I did not notice it the first year I was there, which was the summer of 1878, but in all the succeeding summers it has been very bad indeed, the smell is perfectly dreadful.

807. At night time do you take any precaution with regard to the ports?—I am obliged to close all the ports, and keep the deck under the hammocks wet with disinfectants.

808. (*Chairman.*) For how long during the season is that your practice?—For about a month as a rule.

809. (*Mr. Morice.*) Is that from July to August?—It all depends upon the state of the weather; it has been in June and part of July; it was in July last year.

810. (*Chairman.*) Have you adopted that practice every season since you have been on the ship?—No, I have only done it once, that was last July.

811. (*Mr. Morice.*) At what time of the tide do you notice it worst?—At all times of the tide. I do not think it makes any difference.

812. Have you noticed it very much worse at all in the last few years that you have been there?—I think it was worse last year, if anything, than it was the two years before; that is to say, it was worse for a short time, but it was not at its worst above three weeks last year.

813. Do you know the river and the operation of the tide up and down below your ship?—No, I have only a general knowledge of the tides.

814. Have you ever had any of the Thames water analyzed at all?—Yes, two years ago I took some samples and sent them to Dr. Collingridge.

815. That is the medical officer for the port of London?—Yes; he reported that it was "slightly diluted sewage."

*Capt. A. Gillett, R.N.*

1 Aug. 1882.

816. Where were these samples taken from?—They were taken from mid-stream right in the middle of the river.

817. Near the ship?—Opposite the ship.

818. Have you ever had any illness on board since you have been there?—Every July and August until last year we had isolated cases of typhoid fever. One year we had three cases and the other one each, and we could not account for them in any way except from the state of the river.

819. Have you used the water of the river for any purposes at all on board the ship?—We use the water for the purpose of washing the upper deck in the winter, and for washing the boys, but not now, not in the summer.

820. Why have you discontinued?—Because of the bad state of the water in hot weather.

821. (*Dr. Williamson.*) Is the water ever used for washing your kitchen utensils?—Yes.

822. In summer as well as in winter?—No, we do not use any river water in summer, when it is in a bad state; but just now we are using it for the purpose of washing the upper deck at high water.

823. (*Mr. Morice.*) Do you occasionally lift your mooring chains?—Yes; last year we parted one of the mooring chains, and the conservancy replaced it, and my attention was called by their officer, Mr. Wood, to the state of the cable, pointing out that it was all covered with sewage.

824. Did you see that?—Yes, he called my attention to it. I went on board the lighter to see it.

825. Do you find that there is anything peculiar in the state of the boats or the oars which there was not before?—When the river gets slate-colour, which it does in the summer, the oars and the blades all turn black, but it has not been the case yet this year. Two days ago the river began to smell, but the last two days it has gone off again. The river began to change colour a few days ago, but it is clearer now again on account of the cooler weather.

826. Could you tell us, if sewage is put in about Woolwich, or Crossness, or Barking about high water, how far you consider it would go upon an ebb tide?—It might go 15 miles perhaps, but I do not speak with any authority upon that point.

827. Of course you are at Woolwich, that is above Barking and Crossness?—It is three miles above, I should think; I have not measured it.

828. And you find the sewage comes up to there?—Yes, it comes up to us; the whole bed of the river I believe is covered with it. It sinks, and when the temperature rises to a certain point it rises with it. It appears as if gases exploded in the bed of the river, because it comes up and spreads all over; it comes up in great masses of black stuff, sometimes as big as this room.

829. (*Chairman.*) At what time of the tide is that especially observable?—At all times of the tide when the river has that peculiar slate-coloured appearance.

830. Without being disturbed?—Without apparently being disturbed in any way, and it is worse when the steamers pass, at low water especially, because they stir it up.

Cross-examined by Mr. MICHAEL.

831. Is it your theory that the floating particles of sewage in the tide are deposited at the bottom of the river?—I think they must sink partially.

832. Especially if they have gas attached to them?—My theory is that they are at the bottom; that the whole bed of the river is nothing but sewage.

833. But let me examine your theory; do you tell the Committee that it is your impression that bodies specifically lighter than water sink to the bottom?—No, they would not if they were specifically lighter than water.

834. Did you ever examine the sewage passing into the river?—No.

835. Even if the particles were heavier do you think that in the flood of the river they would fall at once?—Yes, if they were heavier they would, I think.

836. Whatever the velocity of the stream?—Yes, I presume they would sink.

837. Now, you have stated that a piece of chain was covered with sewage; how did you discover that it was sewage?—My attention was called to it by the man who was at work.

838. But your mind would be very slightly affected I presume by the fact of your attention being called to it; now what made you think it was sewage?—By the smell.

839. But have you never seen the bottom of a pond into which there is no sewage discharged?—No.

840. You have never seen these black masses, some of which come to the surface?—No.

841. You have never studied the phenomena of the bottoms of ponds?—Never.

842. Where did you ever see river mud which did not smell badly?—I have seen it.

843. Where?—If I were to take the river mud off the bank at Woolwich it would not smell probably.

844. Do you not know that it is the characteristic of the Thames mud that it does smell very badly after a time?—No.

845. Have you taken any samples?—Only during one month.

846. How do you know that it only smells in that month if you have only taken it at that one time?—I know I can smell it 30 feet above the level of the water.

847. That is to say, the banks of the river under a hot sun give off a bad smell?—There is no bank of mud close to the ship. It is washed away there.

848. Is there no bank near your ship?—No, unless there is a ship lying there which banks it up; but if there is no vessel at the breaking up yard, close to the "Warspite," the tide washes it away.

849. Now as to the sewage upon your chain. Is it your opinion that the sewage has been washed out of the outfalls, and has gone down the river and come back and deposited itself upon that chain?—Yes.

850. How many boys have you under your charge?—200.

851. What is your mortality?—The boys are remarkably healthy.

852. What sickness have you?—Just at the present we have seven boys down, but they are with cuts and bruises and things of that sort.

853. Will you eliminate those and take the rest?—We have no sickness beyond that.

854. What is the average age of your boys?—They come in between 13 and 16, and they stop about a year; the average age would be 15.

855. Mortality nil, and sickness consisting only of cuts and bruises?—Yes.

856. (*Chairman.*) Where is your ship?—Near Charlton Pier; we are exactly off the western end of the dockyard.

857. (*Dr. Stevenson.*) With regard to the samples you have spoken of as being diluted sewage, at what time were they taken?—They were both taken at the last quarter of the ebb, before flood.

858. (*Chairman.*) When was the cable you have referred to taken up?—Last year.

859. Do you recollect whether the river was low at the time?—I think it was in September, but I am not quite sure, and about low water.

Re-examined by Mr. MORICE.

860. At the time when you saw these gases, or large pieces of black coming up to the surface and spreading, was it very hot weather?—It was.

The witness withdrew.

Adjourned to Friday next at half-past 1.

# THIRD DAY.

## Friday, 4th August 1882.

PRESENT:

SIR JOHN COODE IN THE CHAIR.

PROF. ALEXANDER WM. WILLIAMSON, Ph.D., F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E.
WM. POLE, ESQ., F.R.S., *Secretary*.

4 Aug. 1882.

861. (*Mr. Lumley Smith.*) At question 718 of the notes, the Commission asked whether they could be furnished with Dr. Harry Leach's Report, which had been referred to by Mr. Netten Radcliffe, in his memorandum which was read to you upon the last occasion; I have that report before me, and am prepared to read it if the Commission would wish.

862. (*Chairman.*) If you are going to examine upon the report you had better read it, as we should like to have it upon our notes.

863. (*Mr. Lumley Smith.*) This is dated :—

"Port of London, Sanitary Offices, Deptford, S.E.,
"GENTLEMEN, November 12th 1875.

"IN accordance with instructions received at your last meeting on the 11th ultimo, I have the honour to submit a detailed report as to the origin and progress of an epidemic of enteric (typhoid) fever that has recently occurred on board the reformatory school ship 'Cornwall,' moored off Purfleet.

"Having received early information of the outbreak from Captain A. Morrell, the Superintendent of the ship, and also from the authorities of the Seamen's Hospital at Greenwich, I visited the vessel on the 7th ultimo.

"From evidence adduced, it appears that, as long ago as the 14th of September a boy named Edgecumbe, employed to assist the cook in the galley, was attacked with the disease, was affected with it three or four days at least before admission into the sick bay, was in the sick bay five or six days, and was eventually removed to the Seamen's Hospital. Before removal from the deck on which he ordinarily slept, with other boys, to the sick bay, he used the common closets in the bows by day, and the movable pan or pail on the deck at night, and during his stay in the sick bay he used an ordinary fixed closet in the bay. This closet discharges into the river by a distinct pipe, the lower end of which is usually above the water line. He had been on shore in Purfleet village five days before the commencement of his illness, and there had tea without milk and bread and butter.

"No further cases occurred until the 2nd of October (*i.e.*, 18 days after the first case), when Mr. Glen Bott, surgeon to the ship, pronounced three of the boys affected, on the following day, two, and on the 4th several more. On the 6th 20 boys were under treatment at the Seamen's Hospital, on the 12th a total of 38 cases were reported; on the 25th six cases were taken to St. Bartholomew's Hospital; and on the 27th and 28th 41 pronounced and suspected cases were removed to your hospital ship 'Phin,' and placed under the care of Dr. Whitcombe. Although the epidemic manifestly declined on or about the 1st instant, a total of 79 cases have up to the present date occurred out of a complement of 261 persons, one of these cases being the carpenter of the ship. One death only is recorded.

"It is evident from the foregoing history that this outbreak must have been due to a common cause, and thus must be sought for in the atmospheric surroundings or in the food or drink. It is right, too, to premise that the epidemic may have been set in motion by the boy Edgecumbe.

"On the morning of the 8th ultimo, accompanied by Mr. Glen Bott and one of the officers, I made a thorough inspection of the ship, commencing at the keelson. The water in the pump well was quite sweet, but there were several small pools of water in the neighbourhood of the keelson that were strongly impregnated with sulphuretted hydrogen. All the water tanks in the main hold had been very recently lime washed, and appeared clean and in good order, but the three foremost on the starboard side contained a considerable amount of deposit. All these tanks are connected. All parts of the ship below the lower deck appeared fairly ventilated, except a small space forward in front of the magazine, which was damp and very 'stuffy,' having no visible means of ventilation when the hatchway is closed. The air of the main hold has free access to the inhabited decks through the hatchways, which are covered only by wide rope network.

"The larger half of the boys sleep on the lower deck, on which there are no fixed closets, and which is entirely clear fore and aft, except a small range of officers' cabins on each quarter, and a storeroom aft. The in-cast ventilation is effected by means of wide tubes, that brings the air from the side scuttles in at the bottom of the deck, the hatchways acting as upcasts. On midnight visits paid to this ship, both in summer and winter, I found the deck very well ventilated. Large buckets are used as urinals, and the contents are emptied next morning into the latrines above.

"The smaller half of the boys sleep on the middle or 'mess' deck, in which also there are no fixed closets. There is a somewhat objectionable sink on each side of the deck in connexion with the washhouse (which is forward), and a small tank amidships, into which water is pumped from below, and from which the boys and officers derive their drinking water.

"There are on the main deck forward three fixed closets flushed by Thames water from a tank above; two of these are always under lock and key, and the third, above mentioned, is in the sick bay, which sick bay is inconveniently situated for efficient ventilation, being close to the galley, and so necessarily bulkheaded to the upper deck. It remains but to record that the closets or heads are in the usual position at the bows, on a level with (or strictly speaking, somewhat below) the upper deck, and although the inclines below the seats are steep, the closets are imperfectly emptied and cleansed by a tolerably frequent flushing by water pumped from the river direct into the trough.

"It is not necessary here to particularise the scale of diet, but it is proper to record that no milk is given, that all water used in the galley is drawn from the same source as the drinking water supply on the mess deck, and that the boys are said to drink, as a rule, a very large quantity of water at frequent intervals. The water supply is obtained from the Grays Waterworks Company, and the main from which it is drawn is about 12 miles in length, and supplies, before it reaches Purfleet, several villages and a large number of isolated houses. The 'Cornwall' supply had, until the outbreak occurred, been drawn from a small pipe connected with this main, and sent direct, by means of an ordinary hose, over the bank into an open boat, conveyed in bulk in this open boat from the shore to the ship, and then pumped into the tanks.

4 Aug. 1882.

This boat in the intervals of work is moored at the ship's side, close to the galley scupper, and not far from the discharge pipe of the sick bay closet. It is important to notice that the adjacent foreshore is frequently covered with decomposing sewage, brought by a strong ebb tide from the metropolitan main drainage outfalls at Barking and Crossness.

"Having regard to the above facts, it is abundantly evident that the water might have been fouled from several sources after it has left the shore, and before it is discharged into the tanks of the ship. Two analyses that have been made separately and independently prove this to be the case, inasmuch as they show that the water taken from the tank on the mess deck contained a large amount of organic nitrogen, that it contained more than three times as much organic matter as the water obtained from the standpipe on shore, and was wholly unfit for drinking purposes.

"I did not, therefore, wait for the results of further investigation, but at once submitted the following recommendations to the authorities of the 'Cornwall' for immediate adoption, having previously had the advantage of an interview with Dr. Buchanan on the subject at Whitehall:—

"(1.) The shore water pipe to be carried to a point immediately opposite the ship, and a flexible hose (attached to a light chain cable) to connect this pipe directly with the tanks on board.

"(2.) Pending this arrangement tanks to be used in the water boat.

"(3.) All tanks on board the ship to be emptied, refilled, and charged with Condy's fluid.

"(4.) The hold, and all places under the lower deck, to be fumigated at least two successive days with sulphur and charcoal.

"(5.) The space in front of the magazine, above referred to, to be ventilated.

"(6.) All water 'settlings' near the keelson to be sponged out and charged with carbolic acid.

"(7.) All fixed closets on the main deck forward to be abolished.

"(8.) The present heads to be removed, and others substituted, the troughs of which should be lined with slate; the troughs to be partly filled with water and emptied at regular intervals, or (as I think better still) supplied with a small but constant stream of water from tanks fixed in the hammock nettings, or elsewhere above.

"(9.) To alter, at an early period, the present position of the sick bay, so that some amount of ventilation may be secured by leaving the bulkhead about waist high.

"I have since recommended:—

"(*a.*) That the ship should be entirely vacated for at least a fortnight in order that a thorough examination and cleansing may be made.

"(*b.*) That one of Crease's filters shall be placed upon the mess deck in lieu of that now in use, through which all water used for drinking purposes shall pass.

"(*c.*) That the drinking water shall also, if possible, be boiled.

"The last two recommendations were made because appended results of the analyses proved that the water, even as received from the shore, is not free from sewage contamination, and the enclosed copy of a letter from Professor Abel, of the War Office, confirms the statement. The inquiry, therefore, is incomplete until the exact locality of contamination of the water is found. But there can be little doubt as to the harmful influence of the metropolitan main drainage outfalls having regard to the fact that the ship is very close in-shore, and is moored fore and aft, and, moreover, that a majority of the boys affected messed on the starboard or shore side of the ship.

"It appears very desirable that an exhaustive official investigation should be made into the quality and conveyance of the water supplied by the Grays Company, so that the exact locality of its pollution may be ascertained, and with this view I have to suggest that a copy of this report be sent to the Local Government Board for the information of the medical officer.

"I am, gentlemen,

"Your obedient servant,

"HARRY LEACH."

Then there are two analyses of water.

864. (*Mr. Michael.*) Now in order to make this outbreak of fever complete I hold in my hand a report to the Local Government Board which definitely settled what this fever was. This is Mr. W. H. Power's report to Dr. Buchanan of the Medical Department, dated March 15th, 1880, Mr. Power being sent down by the Local Government Board in order to investigate the epidemic on board the ship "Cornwall."

865. (*Mr. Lumley Smith.*) Is that the same epidemic, the one I have been reading about is in 1875, this seems to be a different affair altogether.

866. (*Chairman.*) I understand the report of Dr. Leach's is made in November 1875.

867. (*Mr. Bidder.*) Then I think that must be the same epidemic as the one I read the report upon from Mr. Netten Radcliffe; but I understand there have been two outbreaks, one that of 1875, which my learned friend Mr. Lumley Smith has read Dr. Leach's report upon, and upon which apparently the Department sent down Mr. Netten Radcliffe; and one in 1879, and my learned friend Mr. Michael will read the report in regard to that.

868. (*Mr. Lumley Smith.*) I am in the hands of the Commission, but we have not heard anything of an outbreak in 1880.

869. (*Mr. Michael.*) Yes, we have the Captain Superintendant of the "Cornwall" speaking to it.

870. (*Chairman.*) Let us have it altogether, make it as continuous and connected as you can. Was this particular report referred to by the officer of the "Cornwall"?

871. (*Mr. Michael.*) I do not know that he did refer to this particular report, but he referred to the outbreak to which this report had reference.

872. (*Mr. Bidder.*) At question 684, in answer to Dr. Stevenson, he said that he had 10 or 12 cases of typhoid fever about four years ago, that was in 1878.

873. (*Mr. Michael.*) Now here is the report upon these cases of typhoid, and I have merely cut out those portions of the report which are specially applicable on account of the various matters, (I will put in the report for the Commission to see), which the Captain Superintendent mentioned with regard to the use of water impregnated with sewage, which is the matter before the Commission.

874. (*Mr. Lumley Smith.*) If the Commission wish to have a report of this sort, one does not wish to stand in the way of its going upon the notes, but one is unable to ask any questions about it not having seen it before its going upon the notes.

875. (*Mr. Michael.*) Nor could we with regard to Dr. Leach's.

876. (*Mr. Lumley Smith.*) That was furnished because it was brought in by Mr. Netten Radcliffe's report.

877. (*Mr. Michael.*) The report states:—

"In regard of possible influence of river-borne sewage, bathing and swimming of the ships' company in the river, and washing of decks with river water, received attention. As to bathing, all hands bathed for the last time for the season on the 15th of August. Only boys learning to swim, some 24 in number, continued their lessons until the 8th September. Bathing seems to be excluded as a factor in the outbreak from the circumstance that the interval between the occasion of the last bathing and the date of the outbreak, a period of upwards of five weeks, far exceeded any known limit of the incubation period of enteric fever. On the other hand

swimming, though not thus excluded, was set aside from the fact that one only of the 24 boys learning to swim was included in the first group of sufferers by the outbreak."

Now we come to what was mentioned by the Captain Superintendent, viz., the washing or sluicing of the decks with Thames water.

"Washing, or rather sluicing of decks with river water, could not as a possible cause of the outbreak be excluded, but on the other hand there was nothing whatever to show that it had in fact any influence for harm. And so with any emanations, there may have been from the river itself, or from the foreshore."

Then on page 5 the Report continues:—

"The animal food of the boys though varied day by day (fresh meat four times a week, and cheese, suet pudding, and salt meat each once), was the same every Sunday, every Tuesday, every Wednesday, every Thursday, every Friday and every Saturday; but on Mondays could vary. Monday was indeed always a boiled *salt meat day*, but the *sort* of salt meat consumed on Mondays differed from week to week. As a rule it was alternately salt beef and salt pork, now and then it happened that either one or the other constituted dinner on *successive* Mondays, and occasionally a dinner of the one was supplemented to some extent by the other."

878. (*Chairman.*) Do you think that this part of the report is material.

879. (*Mr. Michael.*) I shall show that it is most material. Then the report proceeds—

"Salt beef, therefore, and salf pork came under suspicion, for either of them might by this method of consumption have been related to the grouping of the graver cases on or about certain Tuesdays; and further it was ascertained that a fresh cask of each came into use shortly before the outbreak. Suspicion of this sort once aroused settled naturally on pork. Not indeed on account of so-called typhoid fever of the pig (which is not known to be transferable to man), but for a wholly different reason. It occurred to me that if pork had had to do with the outbreak, some of that (224 lbs.) of the cask newly taken into use *might have been trichinised, and that the disease therefore from which the boys suffered might not have been enteric fever at all, but trichinosis.* It will be observed that a theory of trichinosis seemed exactly to fit the conditions assumed as requiring fulfilment. A newly broached cask of pork came into use shortly before the occurrence of the outbreak. The pork was consumed by the boys alone. Portions of the pork not thoroughly well cooked might form but a small proportion of a total dinner for the boys, and might therefore have been comsumed on particular days within the limits of one or two messes, and thus (if such portions happened to be infected with trichina) the incidence of the severer cases on a particular mess or messes might have been brought about. Again, pork might very well have been consumed on two successive Mondays, and after that, not until a fourth Monday, and thus the specialties of the time distribution of cases, notably the peculiar grouping of the graver attacks, might be accounted for, while the great diversity of duration of illness would be quite intelligible. Trichinosis in its incubation period, and in the duration of the illness resulting from it, has been known in outbreaks of the disease upon the Continent to vary very greatly. Probably the persons who have eaten most largely of trichinised flesh, or who have eaten it in a condition most nearly approaching a raw state, suffer soonest (sometimes within 24 hours), and most severely from trichinous disease. Many persons who have certainly partaken of trichinised flesh, but who have done so sparingly or in a fairly cooked state, have escaped the disease altogether, or have had merely trifling illness of undefined commencement and end, and occurring many days, even some weeks after the infective meal. Other evidence, too, seemed to support the theory. It was now ascertained that the use of pork on board the 'Cornwall' had, owing to misgiving as to the wholesomeness of such food, been discontinued shortly before the cessation of the outbreak; further it was learned that the pork in question was 'American pork,' exceptionally obtained from a firm in Bristol; and more, that it consisted solely of 'belly pieces,' and therefore of parts of many pigs, and of those parts most likely to be infested with trichina."

Then it goes on with regard to the theory and with the clinical records, and then on page 7 the report proceeds:—

"It was now, upon reaching this point, that it came to be pretty clearly seen that an outbreak, characterised as this one was in the bulk of its cases by simple continued fever with gastero-enteric disturbance, might just as well have been related to trichinosis as to enteric fever, the fact of certain of graver cases of the outbreak taken collectively presenting most of the symptoms characteristic of enteric fever seeming to lose significance beside the circumstance that these very same cases presented, collectively, many symptoms that might be referable so trichinosis. So that at this stage of inquiry it had become obvious that need for direct evidence respecting the nature of the outbreak had become imperative, and in this sense I reported to the medical officer of the Board."

Then he says what has specially directed his attention to the matter, and I ought to tell you that only one boy of this number died during this so-called "epidemic of enteric fever." Then the report proceeds:

"Application was therefore made by the Board to the Home Office for an order for exhumation of the body of Pierce."

That was the boy who died.

"An order being granted conditionally on consent of the friends of the boy being first obtained, and on the understanding that the exhumation and necessary re-interment of the body should be carried out under the auspices of the Sanitary Authority of the district in which burial had occurred, I set myself to procure this consent and to make the requisite arrangements. This having been done, the examination of the body took place on the 6th December. With the consent of the Board, Dr. Cory (who had previously assisted in microscopic examination of the pork) was associated with me at the necropsy, and in the pathological investigations which followed."

Then he goes on to state what are the appearances, and how much they found the body better, and with less decomposition than they had expected. Then the report goes on.

"Further examination was carried out conjointly by Dr. Cory and myself. I think it right to put on record minute technical details,"

and so on, with respect to the examination, especially with regard to enteric fever. I need not trouble you with that, you will see it does not arise upon this point. Then the report proceeds:—

"More thorough examination of the mesenteric glands than had before been practicable revealed a few only enlarged, and none were bigger than peas. The other organs afforded no evidence for or against enteric fever. It thus appeared after detailed examination of the viscera habitually implicated in enteric fever as had appeared from the original necropsy, that with

4 Aug. 1882.

all allowance for decomposition, no such anatomical changes as are characteristic of enteric fever toward the end of the third week of its duration were to be found, and the conclusion now seemed warranted that whatever had been the nature of this boy's fatal illness it certainly had not been enteric fever.

"This conclusion was more than confirmed by the results of microscopic investigation conducted with reference to trichinosis. In the very first specimen examined, a few fibres from one of the abdominal muscles, was found a wandering and living trichina, and further search revealed the presence of these parasites in most of the muscles examined. Although tolerably abundant the trichinæ could not be said to infest (in the common sense of the word) any of the muscles, except, perhaps, the diaphragm, and in none of them had the parasite reached the stage of encapsulation. Except the first found no trichinæ exhibited active movement, and comparatively few had attained, as had that one, their full growth as muscular parasites. In specimens of this sort the internal structure and organisation were under a high power ($\frac{1}{12}$) readily made out, the parasites having altogether resisted decomposition, and most of them having probably died only a short time before examination. The smaller, not fully grown muscular trichinæ, on the other hand, had seemingly all long since died. Their outline had become indistinct, their interior granular, and their structure could not be made out. Many were found broken up. Examination of the decomposing contents of the small intestine failed to find any parent trichinæ, but by scraping the under surface of the folds of mucous membrane of the bowel, brood trichinæ in considerable numbers were obtained. These had apparently all died, and their structure could not satisfactorily be made out.

"Doubt could no longer exist that this boy died from acute trichinosis. Not only was the presence in his body of the actual parasite demonstrated, but the results of microscopic examination pointed to the parasites as having played a very active part in the production of his illness, and were, indeed, precisely such as might have been anticipated in a case of early death from trichina disease. Death took place in this instance on the 18th day after appearance of symptoms, at a period that is too short to have allowed of universal migration of brood trichinæ, and insufficient also for the attainment of full growth in the muscles of any but early migrants. At the same time the period was not nearly long enough to have sufficed for the full evolution and encapsulation of many (if indeed of any) muscular parasites."

Then he goes on to demonstrate where they were found in small quantities in the diaphragm and elsewhere, and comes to the conclusion, as demonstrated clearly, that all doubts were entirely cleared up, that all these so-called cases of enteric fever were due to the eating of insufficiently boiled pork owing to the mode of cooking which they observed, that is to say, putting the pork into boiling water, so that the outside of the pork became covered with such a coating of fibrine as would not allow the water to penetrate into the interior; and they clearly make out that this so-called enteric fever was really a series of attacks of the disease known as trichinosis, the parasites being traced in the muscles.

880. (*Chairman.*) I gather that Mr. Power expresses no doubt of this particular case being due to trichonosis, but does he say that all the cases are due to trichonosis?

881. (*Mr. Michael.*) I will read you the head-note, "Mr. W. H. Power's Report to the Local Government Board on an outbreak of fever that proved to "be Trichinosis on board the Reformatory School Ship "'Cornwall.' George Buchanan, Medical Department, March 15th, 1880,"

882. (*Mr. Lumley Smith.*) I find by the report of Dr. Collingridge that a post mortem was held upon a boy who died in 1880, and that post-mortem proved beyond all doubt that the boy died from typhoid fever, so that it must not be assumed that every case was due to this trichinosis.

883. (*Dr. de Chaumont.*) Were you aware of the remarks of Professor Cobbold upon that case, as that would be found to bear upon the question. Professor Cobbold did not believe that the animal or specimen found was the real trichina.

884. (*Mr. Balfour Browne.*) He made it out to be an entirely new species, if it were a case of trichonosis at all.

885. (*Mr. Michael.*) It is quite clear that all the symptoms which are diagnostic of enteric fever were absent from the boy who was said to have died from enteric fever. The body not having been in such a state of decomposition as to prevent identification of the whole of the parts, the condition of the peritoneum and of the mesenteric glands, the absence of ulceration of the mucous membrane, being points diagnostic of the disease, and ulceration of the bowels not being the cause of death, all point to its not being a case of enteric fever.

886. (*Mr. Abernethy*). Do you read that with regard to Captain Morrell's evidence?

887. (*Mr. Michael.*) Yes.

888. (*Mr. Abernethy.*) But he does not go so far as 1879.

889. (*Mr. Michael.*) He was rather loose in his answers. He does not specify dates particularly.

890. (*Mr. Balfour Browne*). There is no reference in his evidence to the precise epidemic that Dr. Power was reporting upon.

891. (*Mr. Morice.*) I think it was referred to in the report of Dr. Harry Leach.

892. (*Mr. Michael.*) This will make it clear. This report says, "This inquiry was directed by the Local "Government Board at the request of Mr. Secretary "Cross, to whom application had been made (30th "October 1879) by the School Ship Society for "investigation of an alleged outbreak of fever on "board their ship 'Cornwall.'" This outbreak it was stated had occurred about a month before and was the second prevalence of fever on board within a period of four years. At the end of 1875, indeed, nearly 50 per cent. of the boys had been affected with what was held to be enteric fever. In regard of this outbreak, and also at the request of Mr. Secretary Cross, an inquiry was in March 1877 ordered by the Local Government Board. It was to have reference to the sanitary condition of the "Cornwall," and to a suggestion that the health of the boys had suffered from the outflows of metropolitan sewage at Crossness and Barking. Mr. Netten Radcliffe conducted this inquiry but for various reasons was unable to complete it. A memorandum by him presented to the Board on the subject is dated May 1878. That clearly shows that the whole history of the matter was before them of the two outbreaks of 1875 and 1879.

893. (*Mr. Lumley Smith.*) But the report is headed 1880, and the whole that my learned friend has read is dealing with the outbreak of 1879.

894. (*Mr. Bidder.*) The report clearly shows that this was the second oubreak which Captain Morrell was referring to.

Mr. WILLIAM EGERTON called in, examined by Mr. MORICE.

*Mr. W. Egerton.*

4 Aug. 1882.

895. I believe you are surveyor to the Erith Local Board?—I am.

896. And you live at Erith I believe?—I live at Belvidere now. I did originally live at Erith.

897. For how many years did you live at Erith?—I lived for 21 years at Erith, and $5\frac{1}{2}$ years at Belvidere.

898. How far is Belvidere from Erith ?—A mile and a half.

899. Have you known the state of the river during all that time ?—Yes, I have.

900. I believe you have an office near the river ?—I have, within 10 yards of it.

901. Can you tell us whether during the years you have mentioned there has been any alteration in the state of the river as far as the low-water mark is concerned ?—There has been a very great alteration.

902. It has altered during those years ?—Yes, it has very much.

903. In what way ?—The buoy that was put down by Captain Burstal at the lower ballast wharf, of which I was manager for 21 years, and which was put down at low-water mark ;—

904. (*Chairman.*) What was the object of the buoy, to mark a shoal ?—No, it was a ballast wharf and this was the mooring buoy for the vessels. There were I should say two buoys, they were put down from instructions by Captain Burstal, the lower buoy in 9 feet of water at low water, and the upper in 14 feet.

905. At what date would that be ?—I should think it would be 18 years ago. I cannot quite remember the date.

906. (*Mr. Morice.*) You say the river is altered ; in what way is it altered ?—The lower wharf buoy frequently lies aground, and the water recedes from it some yards, and the upper wharf buoy is frequently aground.

907. Has that been so long ?—I have noticed it the last four or five years, but it gets worse every year.

908. (*Chairman.*) When did you first notice any change ?—I daresay it would be 8 or 10 years ago.

909. What first called your attention to it ?—Because the vessels that lay moored to this buoy could not swing round.

910. (*Mr. Morice.*) Have those buoys ever been moved at all ?—No.

911. You say there is a difference of water from what there was when they were first put down ?—A very great difference.

912.—Can you tell us whether you remember when the outfalls were opened ?—I should think it was 16 or 18 years ago.

913. Do you remember the state of the river before that time. Have you noticed any alteration in the state of the river as far as the colour of the water or anything else is concerned ?—I have noticed a very great alteration.

914. What has been the alteration which you have noticed ?—With respect to the colour of the water, I have noticed the water coming out of the outfalls at different times, and I could see it and trace it down as far as Erith by the different colour.

915. (*Chairman.*) Are you frequently upon the river below Erith ?—No.

916. You do not know what happens there ?—No, not below the district of Erith.

917. (*Mr. Morice.*) Is there any smell or otherwise from the water ?—Yes, a very bad one at times ; when the wind is off the water very bad indeed.

918. What sort of smell is it ?—It is a very peculiar smell. I can only compare it to this, when a cesspool has been emptied two or three days it would smell somewhat similar to what that would smell if it had not been disinfected and cleansed.

919. At what time of the year is that the worst ?—In the summer ; in the warm weather.

920. At what time of the tide ; could you tell us that ?—I should think about half ebb.

921. You are inspector of nuisances, are you not, for the Erith Local Board ?—Yes.

922. And in the course of your duty as such, do you visit the factories upon the river ?—Yes, on the south side of the river, and once or twice I have visited them upon the other side.

923. (*Chairman.*) Does your jurisdiction extend to the other side of the river ?—No.

924. (*Mr. Morice.*) Whereabouts are these which you speak of ? on the south side ?—Yes. If you wish to have them in detail, the first one is about half-way between Erith and Crossness, that is Messrs. Callander and Son's Bitumen Works.

925. That is upon the south side ; how far above Erith ?—Three-quarters of a mile ; those are bitumen works. That is a smell similar to what you get from asphalting in the streets of London.

926. What is the next above that ?—Messrs. Charles Price and Company's Oil Works.

927. (*Chairman.*) Do they refine the oil ?—Yes, they refine the oil.

928. (*Mr. Morice.*) It is engine oil, is it not, that they manufacture ?—They prepare different kinds of oil, and the smell from that is like as if you were enclosed in a small room and half a dozen candles were hung up and blown out.

929. What is the next ?—That is Messrs. Berger, Spence, and Company.

930. (*Mr. Michael.*) Is that the Bellevue Guano Company ?—No, that is done away with.

931. (*Mr. Bidder.*) What are they ?—They are the manufacturers of a particular metal called Spence's yellow metal.

932. (*Chairman.*) Is that offensive ?—No.

933. How would you describe that smell, what is it like ?—There is scarcely any smell from that. The next in our district is Collins' Glue Works ; there is a little smell there, more especially at particular parts of the operation. The next is Procter and Bevington's.

934. Have you yet come up to Jenningtree Point ?—No, not yet. Procter and Bevington are scutch boilers. They boil the refuse they bring from the tanyards.

935. That is the refuse of skins ?—Yes.

936. (*Mr. Bidder.*) What do they make of that ?—They extract the fat from it first and make manure of the refuse. The next is Johnson and Company. I have not been to see their works. It has not been long opened.

937. (*Chairman.*) What process do they carry on there ?—A chemical manure manufacture.

938. (*Mr. Michael.*) Those are the fish manure works.

939. (*Chairman.*) Is that also below Jenningtree Point ?—It is at Jenningtree Point. There is nothing else till you come to the Arsenal.

940. But we were told before that the principal works were between the two magazines.

941. (*Mr. Morice.*) They are just above Jenningtree Point ?—They are nearly all below. Messrs. Price and Callander's are nearer Erith than the others.

942. (*Chairman.*) Then, at any rate, the bulk of them, according to your description, is between Jenningtree Point and Erith.

943. (*Mr. Michael.*) Jenningtree Point is between the two groups. Price and Callander's are below, and the other four the witness has given are above Jenningtree Point.

944. (*Chairman.*) That corresponds with what other witnesses have said.

945. (*Mr. Morice.*) Have you visited all those factories ?—Yes.

946. Did you distinguish the various smells from them ?—Yes.

947. Is the smell you have told us of which comes from the river anything like any of the smells from the factories ?—No.

948. Are you able to say that it is a different smell altogether ?—It is a different smell altogether.

949. Do any of the factories you have mentioned discharge anything into the river ?—Yes, there is one which comes from Messrs. Price's, which is called the "Common Sewer Ditch," that discharges partly into the river.

950. Do you know any other ?—I do not know any other.

951. With regard to those you have visited upon the other side have you noticed smells coming out from these factories ?—A little.

952. Are you able to say whether the smell coming

*Mr. W. Egerton.*

4 Aug. 1882.

from them is like the smell coming from the river?—It is not like it at all.

953. Do you remember whether there was any fish in the river at that part?—Yes, there was.

954. How many years ago would that be?—That would be 24 or 25 years ago. I have caught many myself.

955. Up to what time do you remember fish being caught at all there?—I remember some eels being caught three years ago, picked up upon the mud, they seemed in a dying state, but other fish I have not known caught there for the last seven or eight years.

956. Do you know anything about the Dutch eel boats whether they come up there?—They used to come up to Erith, but they do not come there now, that was the place they always used to come to.

957. Where to?—Erith, off the Crown Wharf.

958. That is in Erith Bay?—Yes.

959. Do you know why they do not come up there now?—Because the water is so bad the fish cannot live.

960. *Mr. Bidder* objected to the evidence as not being within the witness's own knowledge.

961. (*Witness.*) I also know it from being on board the eel scoops, and I have seen them picking the eels out of the well, and saying they could not keep them alive.

962. (*Chairman.*) How long ago was that?—Eight or nine years ago.

963. (*Mr. Bidder.*) What have you seen?—I have seen them picking the "dropped eels," as they call them, out of the water, saying they could not keep them alive.

964. (*Mr. Morice.*) As a fact you know this, that at any rate the Dutch boats do not come up and lie off Erith now?—I do.

965. Could you tell us anything from what you have seen in the river as to the course the sewage takes in going down the river?—It depends so much upon the state of the tide.

966. I will give you the ebb tide, take the top of the ebb, what course would it take going down from Woolwich as far as Erith?—I do not go with my district further than Crossness, but from Crossness I should say a great deal of it goes down the centre of the river.

967. Do you know from your own knowledge how far it would go down upon a whole tide?—I do not know that.

968. (*Chairman.*) The witness has already said that he did not know the river below Erith.

969. (*Mr. Morice.*) Do you know the state of the banks about Erith?—Yes, I do.

970. Has there been any alteration upon them of recent years?—In what way do you mean; do you mean stoning them?

971. In any way?—There has been a large quantity of work done in stoning on both sides of the river.

972. Is there any difference in the way of deposit of mud?—Yes, a great difference.

973. In what way?—In the increased deposit of mud. If you are down by the Corinthian boat house between half ebb and half flood you will see vessels swinging round in the reverse way to what they would in the stream, and often fouling their anchors.

973*a*. (*Mr. Morice.*) Do you know Church Hole?—Yes, it is a little above that I am speaking of.

974. Have you noticed any difference in the colour of the mud that is deposited?—Yes, I have; it is very much darker.

975. Is there more of it about there than there used to be?—Yes, very much.

976. Have you noticed any smell from the mud deposited at low water?—Yes, when the sun is out very hot and the wind is off the water it smells very bad, and I have noticed it when there is a fog. I live upon the hill, and when I am half way down the hill, about from 70 to 80 feet above the level of the water, I get into the smell, and it seems as if I could not get out of it. You can get out of the factory smells, but out of the smell of the river you cannot get, and a very nauseous and unpleasant smell it is.

977. What time of the day are you now speaking of?—About 8 o'clock in the morning when I am coming down.

978. Have you or any of your family ever suffered any illness from this?—Yes.

979. (*Mr. Bidder.*) From what?—From the smells arising from the river, and from living in close proximity to the river. I took my wife to four physicians in less than a fortnight so that I should get the best advice. I saw Dr. Kidd and Dr. Peacock in Finsbury Circus, Dr. Jervis in Thames Street, and Dr. Palfry, and they all advised me to take my family away from the river, which I have done.

980. When was that?—Seven or eight years ago.

981. At what time of the year?—In summer time.

982. (*Mr. Bidder.*) Perhaps Mrs. Egerton is delicate?—Not at all so.

983. (*Mr. Morice.*) Could you tell the Commission anything further with regard to the sewer ditch you have spoken of from one of the factories?—No, I could not.

984. What is it?—It is only a ditch that runs into the marshes, and they turn half their refuse into it before it gets to the river.

985. Is it a sewer?—It was one of the old sewer ditches; it used to drain the marsh.

986. (*Chairman.*) Although called the sewer ditch, are we to understand that it only takes the sewage from these particular works?—It goes through the marshes.

987. It is a marsh drain?—It is a marsh drain.

988. But receives the outfall from these works?—From Messrs. Price's works.

989. (*Mr. Morice.*) It is a ditch or drain going through the marshes?—Yes.

Cross-examined by Mr. Bidder.

990. Let us begin with the health. In the first place can you tell me this: your Erith district is remarkably healthy, is it not?—I believe it is very healthy, as healthy as any of the surrounding neighbourhoods.

991. I believe that the medical officers' reports show a remarkable absence of epidemic disease and a remarkable low death rate?—It is below the average.

992. And in other respects it is a peculiarly healthy district?—I believe it is; some parts of it are much more healthy than others; if you get on the high land it is much more healthy than near the river.

993. Dr. Jessett is your medical officer, is he not?—Yes.

994. Did you see his last report upon the health of the district?—I did.

995. I think he pointed out an extraordinary diminution in the number of deaths?—I believe he did.

996. And a total absence of all epidemics?—I do not know that I could go as far as to say that there was a total absence of all epidemics.

997. But *he* went so far as to point out a total absence of all epidemic, and I see that typhoid fever appears to have been confined to one district, Northumberland Heath; that is a high district is it not?—Yes.

998. Away from the river?—Yes.

999. So that your only case of typhoid fever was upon the high ground and away from the river?—Yes.

1000. How far is Northumberland Heath from the river; any considerable distance?—Yes, nearly two miles.

1001. Now about the Dutch eel boats; do you know when the Dutch eel boats ceased to come up to Erith?—I should say it was eight or nine years ago.

1002. Are you right about that?—As I said before I cannot be sure as to dates.

1003. It is suggested to me that they have not come up to Erith since 1850?—I am sure they have. I was not at Erith at that time.

1004. Possibly that may be so?—I know I have gone on board of them often, and got eels from them many times.

1005. And you cannot say how long ago?—I cannot.

1006. Now about the remarkable smell you have observed off the river, does it come off the mud or off the water?—Off both.

1007. And you have endeavoured to convey an idea of it, which I confess is a little confusing to my mind, that it resembled a cesspool which had been emptied a certain number of days, do you mean that it is not so strong as it might be?—It is not so pungent as it would be if it had been freshly opened, it would be a little more flat.

1008. I see you formed a sort of olfactory scale, a cesspool one, two, three, four, five, six, or seven days emptied. I do not know what would be zero in such a case?—Nor do I know. I have had very little to do with them.

1009. Do you know Johnson's fish manure factory?—I do.

1010. In your opinion how many days of a cesspool being emptied would represent the smell from Johnson's fish manure factory?—I do not know, because since the inspector has been appointed under the Alkali Act I have not gone round inspecting them.

1011. How long ago was that?—Two months ago.

1012. Were Mr. Johnson's works in existence then?—Yes, they were, but they were altering them.

1013. You have not been inside since they have been at work?—Not recently.

1014. Do the scutch boilers carry on their works still?—Yes.

1015. Have you been inside them?—I have many times.

1016. Is it an agreeable smell?—Not at all, but I would rather have that than the smell from the river.

1017. In what direction was the wind when you smelt the smell from the river?—North-east.

1018. You know there are works upon the other side of the river, do you not?—Yes.

1019. Have you smelt them?—Yes, I do a little sometimes, there are some works just opposite, Proctor and Bevington's.

1020. There are Wilson's chemical manure works, do you know them?—I know them by looking across the river at them.

1021. Do you know them by the nose?—Yes, I have smelt them a little sometimes.

1022. Among other things they produce a great deal of sulphuretted hydrogen, do they not?—I do not know what they produce.

1023. (*Chairman.*) Those are above Cold Harbour Point?—They are, one just below Rainham Ferry and one just above.

1024. How would they be with regard to Little Cold Harbour Point?—They would be here (*pointing to the map*), there are two below Rainham Ferry and four above it.

1025. Miller and Johnson's chemical manure works are a little farther down, do you know them?—Those that I refer to are below Rainham Ferry.

1026. Do you know a third factory below that where they make fish manure?—There was one, but it has been closed, whether it is open or not now I do not know.

1027. How long ago was it closed?—It was closed last summer. I went over with Mr. Ogsden to see it.

1028. You have never gone over particularly to see what it was like when it was working?—No.

1029. Do you know just by Rock Ferry there are gas purification and chemical works?—There is one I know but I have not been inside of it.

1030. Do you know Barnes's chemical factory, a little back from the river?—I do not.

1031. Do you know Talaman's chemical works?—No, I do not go over on that side.

1032. Do you know Messrs. Crossfield's works?—Yes, I know Messrs. Crossfield's, but what they do I do not know.

1033. Now how long have you noticed this two days' old cesspool smell?—For five and a half years since I went as surveyor to the board.

1034. But you have been in Erith many years; had you never noticed this two days' old cesspool smell till then?—I smelt it more particularly then.

1035. Within what limits would you have smelt that?—From Johnson's works as far as my district goes beyond towards Crayford. That would be going to Erith, and then turning along the main road to Crayford.

1036. But, taking it along the river, it would be from Johnson's works to Erith?—Yes.

1037. When did you smell it last?—I do not remember; but we have not smelt it so much lately, the wind being westerly. We have had such a continuation of westerly winds that we have had very little smell.

1038. When do you recollect smelling it last?—I could not say. I did not make any memorandum of it.

1039. This year?—Oh, yes.

1040. How long ago. If it is this year you could recollect it. Are you quite sure you have smelt it this year?—Yes, many times. I think the time when I smelt it the worst was in March.

1041. You have not smelt it lately?—I have not.

1042. Have you been to Erith lately?—I go every day.

1043. The last day or two you have had a north wind, have you not?—We have had a little north wind the last two or three days. It depends upon the state of the wind. If it is a strong wind it blows it further away; but if it is a dull heavy day we get it much worse.

1044. I think you said you had seen the water coming out of the outfall?—I have.

1045. And how far have you traced it?—To Erith. I could distinguish it by the colour as far as it ran down the river, and not only the colour, but the streamage as it is called, the corks and things of that sort which go along each side.

1046. You would see the corks?—I do. I could see the colour of the water too.

1047. You would not expect the corks to sink after a mile, would you?—No, certainly not.

1048. (*Chairman.*) Does this discoloration extend over the whole of the river?—No.

1049. Over what part?—Over the centre part more especially.

1050. (*Mr. Bidder.*) Over what part of the river, proportionately, would you see the discoloration?—Over about an eighth part of the river.

1051. When did you see it last when you traced it down to Erith?—In June.

1052. And you traced it in a definite stream as far as Erith in June; were you in a boat?—No, I was on the river bank.

1053. How near the bank was the stream?—Nearly in the centre of the river.

1054. You could see from the shore the distinguishing line or boundary of the sewage in the centre?—It was more defined near the centre in the upper part than it was further down.

1055. So I should suppose. Was it defined at all at Erith?—I did not say at Erith. I said I traced it as far as I walked down, but it was visible at Erith.

1056. And there was no smell?—There was smell.

1057. You said the last time you smelt it was in March?—There was a little smell when I have seen it at other times.

1058. But you say this time, as I understand, hat there was no smell?—This time there was not.

Re-examined by Mr. Morice.

1059. As I understand you the smell depends upon the direction of the wind and also the state of the weather?—Yes, certainly.

1060. You say you have had westerly winds?—Yes.

1061. And has the weather been so very hot as it has in other years?

*Mr. W. Egerton.*

4 Aug. 1882.

1062. It is in hot weather that you have found it worst?—It is.

1063. You inspect these factories in the ordinary way. Have you had to inspect them specially lately?—No.

1064. (*Chairman.*) With regard to the inspector that you spoke of just now, is he inspector of nuisances?—No, he is inspector under the Alkali Act.

1065. But I thought you gave us to understand to a certain extent that your duties had ceased in consequence of the appointment of this inspector?—That was so.

1066. You acted as inspector of nuisances as well as of factories?—Yes, I did.

1067. (*Mr. Morice.*) Now after the appointment of this inspector have the factories been to your knowledge better or worse?—They have been very much better, but this was early in the spring, when I had special instructions to go and see them.

1068. (*Mr. Bidder.*) Was that in consequence of special complaints?—It was.

1069. Made by whom?—By some of the inhabitants.

1070. (*Mr. Morice.*) You inspected them, and was any action taken by the board?—No, only notices were given and some alterations were made in the machinery, in the condensers and furnaces.

1071. (*Chairman.*) Was that in consequence of the report you made to the board?—It was.

1072. (*Mr. Bidder.*) Will you let us have that report?—I can no doubt find a copy of it.

1073. (*Mr. Morice.*) Since that time have the factories been better or worse?—They have been very much better.

1074. You have told us that the smell from the factories is quite distinct from the smell from the rivers?—It is.

1075. Now you have told my learned friend that when you have got upon high land you are all right; have you personally got upon the high land lately; do you live higher up than you used to?—Yes.

1076. Is the part where your house is upon very high ground?—Yes it is 170 feet above high-water mark.

1077. And have you felt the evil effects which you did before?—I have not.

1078. (*Mr. Bidder.*) When was your inspection of these works?—I do not remember the date, but it is some time since Christmas.

1079. Was it this spring?—Yes, this spring.

1080. Was that in consequence of the complaints from the inhabitants of Erith?—Yes, it was.

1081. Were those complaints that the works were a nuisance?—That the smell was a nuisance.

1082. To the Erith people?—Yes, to some of them.

1083. Was there anybody else called in to report besides you?—Yes, Mr. Ogsden, a chemist and expert.

1084. And you found it necessary to order alterations in their machinery and arrangements?—Yes.

1085. In other words you found their complaints well founded?—There was a smell which ought not to have occurred; there was a smell, and it was stronger than it should have been.

The witness withdrew.

Mr. Michael Hind called in, examined by Mr. Morice.

*Mr. M. Hind.*

1086. I believe you are an auctioneer and undertaker?—I am.

1087. And a member of the local board of Erith?—I am.

1088. How long have you resided at Erith?—I have resided at Erith all my life excepting the time that I have been away at school.

1089. I believe you are now somewhere about 50 years of age?—I am 54.

1090. Do you live near the river?—I do.

1091. Can you tell us whether there has been any alteration in the state of the river during the last 20 or 30 years?—There have been great alterations since the opening of the outfall.

1092. You remember that?—I do.

1093. Do you know what the river was like at Erith before the outfall was opened?—It was much purer than it is now; there was not so much sediment.

1094. Has that been very different the last few years?—It increases every year, I consider.

1095. (*Mr. Bidder.*) What has increased every year?—The sewage.

1096. (*Mr. Morice.*) Do you remember whether the water used to be drunk some years ago?—I do; I remember it well.

1097. Can you tell us how many years ago that was?—I should think it was 14 or 15 years ago that it would be drunk; it might, possibly, be even less than that.

1098. (*Chairman.*) Where was the water taken from?—It used to be drunk, or at least used for culinary purposes off Erith; and higher up, say towards the Pool, it used to be drunk.

1099. Taken from the centre of the Thames?—Taken from the stream; the ships used to fill up their "breakers" and take them to sea with them.

1100. (*Mr. Bidder.*) Is not the water brackish at Erith?—It may be a little brackish at very high water; quite high water.

1101. (*Chairman.*) Not at low water, I think?—No.

1102. (*Mr. Morice.*) Will you tell us at what part of Erith you live exactly?—I lived directly on the causeway.

1103. Have you noticed in recent years any difference in the causeway?—It has been lengthened very much.

1104. Could you tell us how much?—More than 100 feet; I should say quite 100 feet.

1105. When was that done?—It has also been raised; it has been made 3 feet 3 inches higher.

1106. When was it altered and lengthened?—It has been added to 20 feet at a time, perhaps, within the last seven or eight years; perhaps the first 20 feet might have been put on eight years ago.

1107. For what reason?—Because the mud grew up so much around it that the causeway was entirely covered. It used to extend only 300 feet, and now it extends more than 400 feet; it is also 3 feet 3 inches higher. When it was 300 feet long there used to be about 6 feet of water at the end of this causeway; in the lowest part of it there used to be a foot side; the towest part of it was where the stone causeway and the wood causeway joined, there used to be a dip there, but still there used to be a foot side to it. It was afterwards considered necessary to run a bridge from the wood portion of the causeway to the stone causeway, so that persons could go along it, and I should say it has been lengthened by degrees about 100 feet. The banks used to be exceedingly steep just outside the causeway. Although there were only 6 feet of water at the causeway end, it used to drop suddenly to 12 or 13 feet of water. There used to be a large yacht drawing 10 feet of water which used to anchor within about 20 yards of the causeway end when it was 300 feet long; she used to swing there and never ground. Now that very portion where she used to lie is quite out of water and dry at low spring ebb. You cannot get to the end of the causeway now that it is 102 feet longer, by two boats' length, by at least 30 feet. On Wednesday last it was quite 30 feet from the causeway end.

1108. (*Chairman.*) You mean it was dry 30 feet from the end?—It was dry.

1109. (*Mr. Morice.*) Has that been so for the last few years, or how long has it been accumulating?—It has been accumulating ever since the southern and northern outfalls were opened, by degress gradually getting more and more.

1110. (*Mr. Michael.*) In the last 15 years?—It may be 16 or 17 years. I do not know exactly when the outfall was opened; I know it was the same year as the explosion, and that was 16 or 17 years ago.

1111. (*Mr. Morice.*) Have you noticed that very much more lately?—It keeps increasing, in fact the causeway at the present time is covered with mud; I was there this morning at 8 o'clock, it was covered with mud even then.

1112. As you have seen it as late as this morning, what kind of mud is it that covers it?—Black stinking mud.

1113. And with regard to the mud deposited upon the banks, has that altered of late years?—It is all the same; the mud that washes over the causeway is the same as that on the bank, because the bank is on a level with it, and the mud washes over the causeway.

1114. Is that the same kind of mud?—It is exactly the same kind of mud.

1115. Has that deposit of mud been going on also for the time you mention, namely, the last 15 years?—It has. At the end of the causeway there must be at least 10 or 11 feet perpendicular of solid mud or muck.

1116. Have you found any smell coming from the mud or the river?—I have.

1117. And what sort of smell is it?—A very unpleasant smell; it is a smell very much resembling a cesspool, a cesspool that may, perhaps, have remained open for some few days; not so strong as if the crown of the cesspool was only just taken off, but supposing the cesspool had been exposed to the air for three or four days, this has about the same smell with it.

1118. Have you noticed the smell much this year?—I have not noticed the smell so much this year as I did last year.

1119. Can you tell me why that is?—Because the summer has not been so hot, that is my impression, and I think there has been also more rain.

1120. When is the worst time of year that you notice it?—In hot weather and when there is a wind from the north (north-east) or east, whenever the wind is touching upon our shore we get the smell of the river very bad, it comes up with the wind, and particularly in foggy weather.

1121. The smell then depends a good deal upon the state of the wind?—It does, because the drift of the wind of course blows it over our shore.

1122. Do you remember whether any fish used to be caught in the river off Erith?—A very great many.

1123. How many years ago would that be?—I do not suppose there has been any fish caught there for eight or ten years.

1124. When do you remember fish being caught there?—I cannot exactly say as to the time, but at one time, before the outfall was opened, a very large quantity of boats used to lie from Church Hole over across towards Rainham Ferry, and they also used to lie in Aveley Bight.

1125. Where is Aveley Bight?—On the other shore, just above Purfleet; and by degrees after the outfall was opened those men have gone down lower and lower, until now they have got down to Lower Hope.

1126. That is to say they have gone from Church Hole gradually to Lower Hope?—Yes simply because their occupation was gone, there being no fish for them to catch.

1127. Do you remember the accident to the "Princess Alice"?—I do.

1128. Did you have to do with a good many of the bodies that were brought ashore?—I did, with 29.

1129. They were brought ashore at Erith, I believe?—They were.

1130. (*Chairman.*) Where was it exactly that the "Princess Alice" came into collision?—Just above the northern outfall.

1131. (*Mr. Morice.*) About what is termed "Tripcock Point"?—Yes, about Tripcock Point, between North Woolwich and Halfway Reach.

1132. Several bodies you say were brought ashore at Erith?—They were.

1133. And I believe you attended to them?—I did.

1134. Can you tell us the state in which you found them?—I found a great many of them, those that had been in the water any time, say three or four days, in a very dirty filthy state.

1135. Was there any smell from their clothing or otherwise?—All their underclothing was saturated with perfect muck, their pockets and everything of the kind, all their clothing was in an exceedingly dirty state, no one would ever think they had been in the water so short a time to see the dirty state that they were in.

1136. Was there any smell from them?—Yes, an offensive smell.

1137. Have you had to do with bodies that were drowned in the river years age?—Yes, with a very great many.

1138. Before the outfalls were opened, I mean?—Yes, years before the outfalls were opened; I had to do with the "Worcester" accident, those boys were drowned very close to where the outfall now is, when the outfall was building.

1139. There were 11 of them, I believe?—Yes, there were 11.

1140. They were brought to Erith, I believe?—Yes.

1141. In what state did you find their bodies—They were much cleaner than those that were drowned in the "Princess Alice" disaster.

1142. I may ask you generally with regard to bodies that were taken out of the water and put under your care before the outfall was opened, what state were they in?—The clothing and the bodies generally were much cleaner than they have been since, and it is feasible, because by rolling about in a lot of black mud they must get in a very bad state.

1143. Have you ever bathed in the river?—Yes, many a time.

1144. Have you bathed in it lately?—No, I should be very sorry to.

1145. Can you tell us whether there is anything else in which there is a difference between the mud which is on the banks now and what there used to be?—There is a very great deal of difference in the colour at the present time, and there is a very great difference in the quantity; at one time you would go to the water's edge and get no more mud than just a little over your ankles, whereas now if you were to go to the water's edge it would be over your middle.

1146. (*Dr. Williamson.*) What was the colour of the mud formerly?—It was a lighter colour than it is now.

1147. (*Mr. Morice.*) Used there to be a smell from it like there is now?—There was not an offensve smell like there is now; not anything at all like it.

1148. Do you know the smell which comes from the factories?—I do remarkably well.

1149. Is the smell which comes from the factories anything like the smell you have told us of that comes from the water?—It is perfectly different, people who have been living any length of time in the neighbourhood can detect the factory works smell directly, and also they can detect the smell from the river.

Cross-examined by Mr. Michael.

1150. Is the smell from the factories all alike?—No, it is not all alike.

1151. Are you able to discriminate from which of the factories the smell comes?—I am able to tell whether a smell is from a factory or from the river.

1152. That is not the question I ask. I asked you whether you could tell from which of the factories the smell came?—Yes, I can in some cases; there is the asphalte manufactory which you can tell directly. Then again Price's candle factory has the smell of a candle burning down in the wick or in a candlestick.

1153. That is not pleasant, is it?—Not particularly. Then there is a manufactory of guano.

1154. That is pleasant no doubt?—But it does not smell like the river.

*Mr. M. Hind.*

4 Aug. 1882.

1155. None of them smell like the river?—None of them are so bad.

1156. The faint smell from the river is much worse than the guano factory or the burning of a candle down in the stick?—Not at all; the river is the worst.

1157. You are a distinguished taster and tester of smells apparently?—I have had much experience.

1158. You have had experience no doubt, and you have confined your evidence to the southern side?—I have spoken of the works upon the other shore as well.

1159. You are a member of the local board of Erith?—Yes, I am.

1160. And the last witness is your inspector of nuisances?—He is.

1161. And you appear to have compared notes with him before coming here?—Not at all.

1162. It is curious that you should both have hit upon the same simile of a cesspool open for so many days. Now you say the smell is more particularly distinguishable when the wind is from the north-east?—From the north.

1163. The wind from the north would bring to your discriminating cognisance the smells of the factories upon the river?—It would bring the smell of the factories to Erith.

1164. Of those upon the other side?—Of those upon the other side as well as these.

1165. Now do you know a gentleman named Crossfield who has manure works on the north side?—I do not.

1166. Do you know the candle factory upon the other side nearly opposite Price's works?—I do not know that. I know there are works, but I do not know them particularly.

1167. The Rock Portland Cement Company?—I do not know their works.

1168. Messrs. Salaman's works, the gas purification works, Messrs. Miller and Johnson's chemical manure works, and the fish manure works; in fact, there are altogether nine works an the north side, and their smells would be brought directly, supposing they had any smell, across the river with a north wind to you; have you ever taken pains to ascertain whether any smell came from any of those nine works?—We have taken pains as far as the local board is concerned with regard to the smell coming from them, but it is a very different smell to the smell from the river.

1169. Then there are smells from them?—No; as far as those upon our own side are concerned, we have taken steps with regard to them to prevent the evil.

1170. But a north wind would blow direct from the north shore to you?—No, it would blow right over us from our own side.

1171. Kindly apply your mind to the question. Would it not blow directly over you from the other side of the river?—You have made a mistake about the bend in the river.

1172. Now all these factories on the other side are out of your jurisdiction?—They are.

1173. And you have never smelt any bad smell coming from them?—They have no doubt a smell coming from them as well as from the others.

1174. When did you smell them last?—I do not know whether I have smelt them. I cannot tell them one from the other; but as far as the factories upon this side go, I can distinguish between them which is which.

1175. I understood you to say you never smelt them upon the other side?—I do not know what they are.

1176. You have positively told the Commission that when the north wind blows a certain bad smell has its origin in the river. Now I put it to you that upon the coast opposite to your place there are nine works giving off bad smells?—They are not at all opposite to us, they are very much farther up.

1177. (*Mr. Abernethy.*) They do not appear to be opposite to Erith.

1178. (*Mr. Michael.*) A dead north wind would blow the smell from Wilson's works, Miller Johnson's chemical manure works, and the fish manure works. They are directly in a line with Erith.

1179. (*Witness.*) But you said directly opposite Erith.

1180. (*Mr. Michael.*) They are directly opposite as far as the north is concerned, if you were drawing a line?—I should say it is three miles from Erith Causeway up to either of these factories. They are a long way above Erith altogether, upon the opposite side of the river.

1181. (*Chairman.*) It is apparently more like two miles.

1182. (*Mr. Michael.*) It is a mile and a quarter. I have measured it upon the Ordnance map. Here is the church (*pointing to the map*)?—But the causeway is half a mile from the church.

1183. It is a mile and a quarter from the causeway to the fish works upon the opposite side of the river?—I should have thought it would have been much more.

1184. As a member of the Local Board of Health did you several months ago direct your inspector of nuisances to inquire into complaints which had been made to you as to the smell arising from the manure and other works within your own jurisdiction?—Yes, he was appointed to do so.

1185. But you had had complaints previously with regard to these works?—Yes; but that did not apply to the works upon the other side of the water.

1186. Can you apply your mind; I said within your jurisdiction?—Yes, there was complaint.

1187. Could you furnish the Commission with the complaints that were made which gave rise to that action which was taken by the Board?—I cannot say now.

1188. Were they brought before you officially as the urban sanitary authority?—I believe they were.

1189. Is a record of them to be found in the books?—No doubt there is in the minutes.

1190. Would you kindly allow us to see the complaints that were made, and what was done in consequence of those complaints?—As far as I am concerned, you are quite at liberty to do so.

1191. Having paid so much attention to the mud which is deposited on the causeway, have you paid attention to the flow of the river in the last 15 years?—Yes, I have.

1192. Has it in any way changed, in your opinion?—There is a very great change off Erith now as far as regards the current.

1193. Where does the current go now?—The current is further out in the stream than it used to be.

1194. Is it not deflected out towards the other shore?—Do you mean the flood or the ebb?

1195. Take the ebb.—The ebb tide just after high water sets down to about opposite Rainham, and then off into Erith Bight, and then down to Aveley Hole just above Purfleet, and down Long Reach; it goes from angle to angle.

1196. Is that in any way different from what it was 15 years ago?—There is not so much current now as there was 15 years ago upon the shore owing to the quantity of mud, which prevents the opportunity of there being so much current, though it takes the same direction; the water cannot flow if there is mud to prevent it.

1197. Was the current there when the mud began to be deposited?—The current used to run there.

1198. And while the current was running the mud was deposited?—Yes it was to a large extent; the current used to run close to the causeway.

Re-examined by Mr. Morice.

1199. I take it that inshore in Erith Bay there is a large amount of mud?—Yes, a large amount of mud, so large that it is for anyone to see; it is not something that you can put out of sight.

1200. And you say there is not the same strength of tide in there now as there used to be?—No, it is impossible, simply because it is all filled up with mud; how can the water be there if it is filled up with mud?

1201. And at low-water mark is not there a good deal of slack water in the bay?—There is quite an eddy now. Where the Corinthian Yacht Club is, all those boats are continually doing a whirligig in this way (*describing the same*), simply because they are all blocked up with mud; there is no water as there used to be.

1202. How far does that extend, to Church Hole?—It runs from below Church Hole, to below Easton and Anderson's works.

1203. Where is that?—The lower part of Erith; all along in front of Erith. *Mr. M. Hind.* 4 Aug. 1882.

1204. You told my learned friend that you had spoken of the southern factories only; those are the only ones you know?—Yes.

1205. And with regard to this particular cesspool smell, it is open for my learned friend to go and smell it himself?—Yes, and then he would be convinced.

Examined by the Commission.

1206. (*Mr. Abernethy.*) When the wind is blowing from the north-east you smell it?—We do, and with a light wind much more than when it blows hard; with a light wind, and when it is foggy weather or not a very bright atmosphere.

1207. (*Dr. Williamson.*) Has that causeway, in your opinion, anything to do with the mud that is collected upon the side of the river; you say that there is more mud deposited of late years, and the causeway has been lengthened also?—That is the very reason for lengthening it, that the mud grew up so much that they could not approach.

1208. You are perhaps not sufficiently acquainted with the river to know much about the matter, but is not the causeway like a breakwater?—Not at all; part of it is upon piles.

1209. (*Chairman.*) What is the length of that part of it?—There would be only about 10 or 12 feet of piling in the middle.

1210. The rest is solid?—Yes.

1211. (*Dr. Williamson.*) And the new part which has been lengthened, is that solid?—That is upon small piles. It is timber or boards run out. It in fact almost settles upon the mud.

1212. (*Chairman.*) Did you rightly understand the question that was put to you by Dr. Williamson as to whether the causeway itself had been the cause of the accumulation of mud to any extent?—Not at all, it has nothing to do with it; the mud is on one side of the causeway as well as the other, but more upon the upper side, which is nearer the outfall. As regards it being a breakwater or anything that prevents the mud washing underneath, I say it is not; there is any amount of deposit 300 yards from the causeway before you come to it, all around the wharves and the piers where there is nothing to prevent it washing away, but still they are obliged to keep gangs of men for the purpose of washing and flushing it into the stream.

1213. (*Dr. Stevenson.*) You spoke of a change in the smell of the mud in the river; is that change in the kind or in the amount of the smell in your opinion?—It is a different sort of smell altogether from what it was when the sewer was opened.

1214. When did it begin to change its character?—It is a matter of degrees; I could not say that it was so much stronger one year than another, but it has been continually getting stronger; last year it was not so strong perhaps because there was a great deal of rain, and this year it has been cooler, and there has been plenty of fresh water and rain.

1215. (*Chairman.*) You are prepared to tell us that there has been a change both in quantity and in quality, in short?—I am. I have been used to boating for very many years, being almost always upon the river in my leisure time, particularly so before the outfall was opened.

The witness withdrew.

Mr. William Cobb called in, examined by Mr. Morice.

1216. What are you?—I am the oldest fisherman there is upon the River Thames now at this present time. *Mr. W. Cobb.*

1217. I think you live at East Greenwich?—I do.

1218. And you have been engaged in fishing upon the river since you were a boy?—Yes, for 60 years; I am 75 years of age now.

1219. Up to about 20 years ago now what was the best fishing ground in the river?—Erith Reach was the principal fishing ground.

1220. What fish did you catch there?—Eels, flounders, whitebait, and sometimes a salmon.

1221. (*Chairman.*) When you say "Erith Reach "was the best," do you mean for Erith people or the best along the Thames?—The best along the Thames.

1222. Of course we can understand it was the most convenient for Erith people, but would you say it was the best fishing ground along that part of the Thames?—It was.

1223. (*Mr. Morice.*) You used to fish the river in different parts?—Yes, from Greenwich to Gravesend.

1224. What part of the river around Erith was the part where you fished?—Erith Bight.

1225. Between what parts of the river?—Between Woolwich and Greenhithe.

1226. What part was the best for fish in the river where you used to fish?—It was all parts of the river; it was not always alike; it varied according to the season. I have caught whitebait off there; I have caught flounders, eels, and shads and all kinds of fish there according to the season; sometimes we have gone to Greenhithe and Halfway Reach, where the sewers are now.

1227. Whereabouts between the places you have already mentioned were the best places for fishing?—That would be according to the season and according to the water.

1228. But you have caught them in Erith Bight?—Yes, the most fish that ever we caught of all kinds was between Erith and Purfleet; that is in Erith Bight, upon the south side.

1229. When did that state of things begin to alter?

(*Mr. Bidder objects to the question as leading.*)

1230. (*Mr. Morice.*) Has that state of things altered?—Very much so, because there is nothing to be caught; there is nothing at all.

1231. When did you begin to find that you could not catch fish there?—About a week after the sewer had been opened, then the fish was a swimming on the top, at least they came up atop, and the swell from the steamboats and one thing and another drove them on the shore, and I could catch them with a basket, because they were all dead. I am a hooker man, that is I fish with hooks and lines, and previously to fishing with hooks we used to catch fish for bait, we used to lay the lines with 1,000 hooks a yard apart up the river, according to the best of our judgment.

1232. Now you say after the outfalls were opened you began to find the fish lying dead; has that continued ever since?—It has continued so that at last we can catch nothing.

1233. Where have you to go to get your living?—It has driven us right away to sea; where we could get whitebait four years ago, which we could do at Greenhithe, we have had to go to Grays, and from Grays to Gravesend, and we are now at Southend and Sheerness, and there is none to be caught, that is, whitebait, as to flounders and eels, there are none to be caught in the river at all.

1234. (*Dr. Williamson.*) Where is there any whitebait?—There is none this side of Gravesend now.

1235. (*Mr. Morice.*) You were going to tell the Commission something about the mode of catching

*Mr. W. Cobb.*
4 Aug. 1882.

bait?—We would catch whitebait and eels in the night, that was for a bait, and we laid the hooks, a thousand hooks, a yard apart upon a string, and we laid that upon the bottom, but now the bottom is in such a filthy state that we should lose lines, hooks, and all; at least I do not say we should lose the lines, but the hooks would be so overlaid with filth that it would break the snoods that the hooks are attached to.

1236. Have you found any difference in getting your nets up as compared with what it used to be?—We could not get them clean if we were to put them in.

1237. Why?—Because they would be corroded with all manner of filth.

1238. How long has that been the case?—Ever since the outfall first opened, it may be 16 or it may be 18 years. I never took that notice.

1239. You have been driven all away, have you not?—Yes, we have been driven further down all of us river fishermen, and I am the oldest.

1240. Did the water use to be drank?—I have known ships take water out of the River Thames at Deptford and Blackwall too, and not only that, but at Erith I have tipped my kettle over and boiled the water and drank it, clear beautiful water, at breakfast and tea, and now I should not like to drink a glassfull; I do not think I should live long if I did.

1241. How is it different now?—I do not know what to call it, it stinks enought to poison you.

1242. What colour is it?—All manner of colours. I cannot tell you what colour, it varies according to high water or low water; it is a different colour according to what way the stream is running. As to the bottom of the river, I could put in my pole and it would stand upright in it, and when I pick it up again and look at the end of it (*exhibiting disgust*).

1243. I understand from you that you consider there is a lot of filthy stuff at the bottom?—I do not know what it is, but it is something that smells very strong.

1244. What does it smell like?—Worse than any closet.

1245. Do you know the causeway at Erith. Well, I walked up and down it some thousands of times I was going to say, and I do not know that I should be much wrong, off Erith Gut, that is the middle between Jenningtree Point and Erith; we used to fish 14 or 15 boats, catching flounders and shads at times, and land at Erith, the beautiful causeway there (I suppose it is since the opening of these sewers) is so corroded that they have been obliged to build the causeway out further and further, and to build another one atop of it, and it is so washed up coming round the point by the tide inside that there is no passage at all, and so they keep on building it and building it till they will build it as high as this place for all I know. I know there is 12 feet clear settlings at the end of the causeway, and it may be more for all I know.

1246. Twelve feet clear settlings of what?—Of all kind of mud.

1247. You know Church Hole opposite the church?—I know it.

1248. Is there much mud in that bay?—There is a great deal of mud now, but it was a hard bottom, a hard gravel bottom. I have laid my hooks and lines there many hundreds of times and caught many thousands of fish.

1249. That is just above what is called the Gut?—That is Erith Gut where there was a good depth of water.

1250. Is there anything like gravel and hard bottom there now?—There is none to be seen whatever.

1251. What is there to be seen instead?—A black filthy stuff, mud. I do not know what to call it, it is all covered altogether.

1252. Has there been a greater amount of it within the last few years?—Yes, it keeps coming up every day there.

1253. When you say comes, does it remain there or does it come and go away again?—No, it never moves, it never can go away when it once settles upon the shore.

1254. Does it get more and more every day?—It gets more and more every day.

1255. (*Chairman.*) Do you not see any difference after there has been a deal of fresh in the river?—The thaw of the ice will make a little difference, it may wash a little of it into the deep water off the shore.

1256. Would not a considerable fresh from the upper part touch it?—No, it would not reach it at the time.

1257. (*Mr. Morice.*) Do you know the mud in the Medway?—Yes, well, I have been travelling in that way 11 years.

1258. Was the mud up near Erith anything like the mud in the Medway?—Equally the same, and nice mud it used to be.

1259. It used to be you say, when was it the same?—I will say 30 years back.

1260. What was the colour of that mud?—It was a bright mud, full of worms, food for fish, it was full of little red worms which I had to use upon the hooks, that was all a nice harbour for fish.

1261. Are there any worms in this part at Erith now?—No, there are no worms or anything else; you will see nothing but a black filthy mud, I do not know what else to call it.

1262. Is there any smell from that mud?—Oh, dear me, I should very much like some of you gentlemen to come down and let me put a staff down and examine it yourselves. I should like to take you down in my boat.

1263. Do you catch any shrimps there now?—No, nothing at all. I have my boats to work now in the Lower Hope, that is the nearest we can come up the river to catch shrimps at the present time.

1264. When did you have to go to the Lower Hope for shrimps?—The last two years, we did get them at Gravesend previously to that.

1265. Do you remember catching eels in the Thames?—Some thousands or hundreds of thousands. I have caught them as high as Woolwich, eels caught with whitebait as a bait, laying the hooks upon the bottom, and hauled them in by the hundred at a haul of all sizes. We have gone to Barking and we have tried all manner of places till we found out the best spot.

1266. Where have you caught them lately?—I have my gear all lying by, they are no use at all to me now. The last time I tried was at Greenhithe, I hauled nothing. I did haul a good many rope yarns and other things I could not describe.

1267. When was that?—About a month back.

1268. And you caught nothing?—I do not know that I shall ever get the stain out of the lines any more.

1269. Do you know what the eel boats coming up the river as far as Erith did?—I remember when the Dutch eel men used to lay out off Erith and they were towed up gradually upon the neap tide to market; now the same persons are obliged to go to Holy Haven and lie off there in the sweetness of the water to keep their cargo of fish alive.

1270. (*Chairman.*) Where is Holy Haven?—About seven miles below Gravesend upon the Essex side.

1271. Near Canvey Island?—Yes, and now they send them up in boxes. They sweep them out of the wells at Holy Haven and place them in large boxes and bring them up to London; they get them towed up as quick as they can astern of anything.

1272. (*Mr. Morice.*) What is the reason of that, do you know?—Because they could not bring them through the sewage water.

1273. *Mr. Bidder* objects to the evidence as not within the witness's knowledge?—I have had hundreds of eels, and I have had to take them out at Gravesend and spread them all over the boat to keep then alive, but when those got up to London I could put them in the Thames water again, but I must not put them in sewage water, as they would turn up directly; if there were two or three left in the well their heads would be about as big as two or three heads, and they would be

all manner of colours, they would be no good whatever.

1274. Would you tell us exactly where you take them up, and where you put them in again?—At Gravesend we take them out when we are coming to market. When we get about the middle of the pool, then we should put them into the water again; they like the London water, it is sweeter.

1275. Have you ever tried putting eels into water since the outfall opened?—I have. The way to kill an eel is to take some of the sewage water that is coming up and throw a live one in and he will lie straight directly, it will kill him quicker than cutting him up in pieces; when they once have a taste of it it is all up.

1276. You know the set of the tide and the course of it pretty well down the river?—I do.

1277. Can you tell us this; if sewage is put in at Crossness at high water where will it get to in the course of the ebb; take a spring ebb tide?—Providing you put a buoy and let it drive, I should say it is all dependent upon the spring tides and the dead tides.

1278. Take spring tides?—I should say Northfleet Hope or Gravesend, I would say it would drive to Gravesend. I have driven there in my boat without touching her or rather without touching the shore, I should say.

1279. It would then meet the flood and come up upon the flood; how far do you think it would drive up upon a flood tide?—Not quite so far as it would upon the ebb tide. If it was upon a spring tide I would say Erith, I do not think it would come much higher than Erith.

1280. Take an ordinary tide?—I would say Erith; it would not come back further than that. But when the sewerage comes out upon the flood tide, and of course it comes out swifter upon a flood tide, it will come up to Greenwich.

1281. (*Chairman.*) But we are told that the sewerage is not let out upon the flood tide, it is let out upon the first of the ebb?—It comes out within two hours of high water till they get a block, you have the flood tide making, and they let it run from the mouth of the tunnel till they get a block.

1282. You are speaking from your own knowledge, are you?—Yes, I am speaking of what I have seen myself.

1283. (*Mr. Morice.*) What do you mean by saying that it was let out upon the flood until there was a block?—When the water comes up as high as the mouth of the sewer then it is shut down and they do not work any longer, and directly they get a sufficient vacancy afterwards upon the ebb tide it rushes out again.

1284. Have you noticed it often within your own knowledge coming out before high water?—Yes, because we are frequently up and down almost ev day; I have been travelling up and down constantly, but not lately, because I have got too old for it now.

1285. But you have noticed it?—I have noticed it daily because I have been towed up astern of steam ships.

1286. And you have noticed it in the way you have told us?—Yes, I have.

1287. Now just another question upon how far the sewage would get. Supposing a portion of the sewage is let out, say four hours after high water, how far would that get?—It would not get far.

1288. How far would it reach?—About Purfleet.

1289. And then meeting the flood how far do you think that portion would get up the river?—Up to Woolwich.

1290. Is there any under current at all in the river when the ebb is making?—Yes, both ebb and flood, of course there is, but not half so much current as there is at the surface.

1291. Is there any backwater in the bays on the way down?—Yes, what we call eddy tides.

1292. Would there be any sort of young tide making up when the ebb tide is making down?—Yes, round the points.

1293. (*Mr. Bidder.*) Under the lee of the points?—Yes, but that does not interfere with the current of the tide, it is only a little portion from the shore.

1294. (*Mr. Morice.*) Do you know whether there is any current below the surface a little before the end of the ebb?—But that does not make any difference to the eddy near the points, anything that is drifting upon the top of the current and going round the point. The top current will turn it round, the underneath current does not interfere with that.

1295. You know what is called the saltings?—Yes, I do.

1296. Do you know whether there has been a great amount of mud deposited which is caused by the saltings?—Not at all. Saltings is a hard substance with wild grass on it, and clay and mud. I have known it to be in big lumps, as big as the table, and what have they done with it; they have repaired the banks with it.

1297. How have they repaired the banks with it?—They have put down planks and the navvies have put it in barrows, because they could cut it like cheese, and they repaired the banks with it. Having piled it up upon the banks they then put the stones against it, and it forms a hard substance.

1298. Therefore, as regards any mud which is deposited upon the banks, do you consider that that is caused by the saltings at all?—No, the saltings are nothing to do with it.

1299. Have you ever lost an anchor in the middle of the stream?—No, but I have been after an anchor, because I am a bit of an under-water man myself. I have been in there up near the sewer.

1300. Have you done that lately?—This last winter.

1301. Do you find any difference in the difficulty you have in regaining it?—I never got it at all, it went into the next world.

1302. To what do you attribute that?—I could not find it because it was all buried.

1303. In what way?—It was buried in the lower part of the river.

1304. (*Mr. Bidder.*) I cannot stand that; you did not find it, and therefore you do not know where it was.

1305. (*Witness.*) No, that was so, but still it was buried.

1306. (*Mr. Morice.*) Did you have greater difficulty in searching for it?

(*Mr. Bidder objected to the question.*)

1307–8. (*Mr. Morice.*) From the search that you made did you find that there was any difference in the mud in the bottom of the river from what it used to be?—We could not get the sweep along. We used to have a sweep line to sweep the bottom first, and if we got hold of it put a chain round it and heave it up; but now we could not get the sweep along because it sunk into the stuff at the bottom, thick and thin; it it was as thick as my arm when it came up.

Cross-examined by Mr. Bidder.

1309. Where did this happen?—In Halfway Reach.

1310. Now apparently you have had a considerable experience of fishing in the river?—I have; I have been 60 years at it.

1311. And did I understand that you were fishing for eels last month off Greenhithe?—We had a try, but caught nothing; we laid a few lines at Greenhithe.

1312. In the way of business?—Yes.

1313. You went there because you thought you would have a chance of getting something?—Yes.

1314. So it was worth while trying?—We thought so.

1315. Nothing had happened up to that time to prevent your trying?—No.

1316. You did not catch any?—Not one.

1317. Has it happened to you before in the course of your 60 years' experience to go and try and not catch any?—No, I do not say it ever happened like that because we always catch a few; 1,000 hooks will not let everything go.

*Mr. W. Cobb*
4 Aug. 1882.

1318. You never did such a thing before as trying to fish and catching nothing?—No.

1319. Not from your youngest day?—No.

1320. You have been more fortunate than I have; now you find your best chance of fish where there is a clear gravelly bottom, not where there is mud?—That depends upon what fish you are going to catch, and what time of year it is.

1321. As a rule for flounders and things of that kind?—For flounders a hard bottom, but for eels we like a softish ground.

1322. But you do not find eels where there is a great accumulation of mud do you?—Not such a great deal, else it would bury the hooks and bait and all.

1323. So that wherever you have a great accumulation of Thames bad mud there it is no use fishing for eels or flounders?—No.

1324. And I suppose it is the same thing with the whitebait?—Whitebait swims always on the surface, within a foot of the surface.

1325. Did you use to catch whitebait at Greenhithe?—We used to catch whitebait at Greenhithe and Grays; that was the last catching which I have seen, but I have caught more off Greenwich than I have anywhere.

1326. But I understand you to say that you used to catch whitebait off Greenhithe two years ago?—Yes.

1327. Are you still in the whitebait line?—Yes, I serve Messrs. Crosse and Blackwell, in Soho Square, with hundredweights of whitebait.

1328. Where do you catch them now, at Grays?—At Southend and Sheerness, and sometimes at Queenboro, that is close to.

1329. You have noticed the factories in the river which have grown up since you knew it first?—No, I do not think I have.

1330. Have you never noticed some works upon the river not smelling quite like your staff you know, but still not the most pleasant smell in the world?—I have not seen much of it running down.

1331. Have you not noticed much smell from the factories?—Yes, I have smelt them, but not anything running from them into the River Thames.

1332. Have you never noticed anything in the way of stuff running in from the factories?—I have not.

1333. Have you never noticed any scum from the factories floating upon the surface of the river?—No, none that was of any consequence, none that would hurt us.

1334. What was the stuff that you saw that was not of any consequence?—What we call the skimmage of the tide between high water and low water wherever it pitches, it is what we call the scum froth.

1335. You say it comes from the factories?—No, I do not say it comes from the factories.

1336. What does it look like, gas tar?—No, I should not say that.

1337. What does it look like?—It has an oily look.

1338. Have you ever seen fish turn up in it?—No, I do not know that I have, because it may go ashore and not come back again; we have not seen it the second day.

1339. Have you ever complained of things they have put in from the factories, and grumbled at them?—No.

1340. Have you never grumbled at all?—No, not as far as I can remember.

1341. Have you never noticed anything flowing in from the factories?—No.

1342. What were the fish you saw turn up upon the top of the water and die?—Shrimps, whitebait, eels, flounders and all kinds of fish.

1343. When was this?—About a week or a fortnight after the sewerage opened.

1344. Whereabouts did you see them?—I saw them at high water; goodness knows where they went to afterwards.

1345. But whereabouts did you see them?—In Halfway Reach.

1346. Were you alone or was anybody with you?—I had an apprentice with me.

1347. Was it on one occasion or upon more than one occasion?—I have seen them for a week or a fortnight afterwards keep gradually turning up from various reaches.

1348. Always in the Halfway Reach?—No, not always in Halfway Reach, because I have not been there every day.

1349. Where else have you seen them?—I have seen them as low as Greenhithe.

1350. Have you seen them of late years turning up in that way?—No, because there has been none to turn up.

1351. Stop a minute; you went fishing last month?—Yes, but there was not many to turn up, not this side of Greenhithe.

1352. When you say that there is not now a good place for fishing opposite Erith Reach, when was the last time you fished there?—I forget the time, because it is so long ago since I was there.

1353. Who asked you to come here and give evidence?—A gentleman who comes from Greenwich, I believe; I do not know his name.

1354. Did you have a meeting about this a week ago?—He asked me if I would collect as many fishermen as I could together, and I did so.

1355. Did you have a meeting at a public-house?—We did.

1356. What was the name of the place?—The "Golden Anchor."

1357. Was that the anchor you lost?—No.

1358. One you often hanker after, I dare say?—No doubt.

1359. How many of you were there there?—About a dozen of us.

1360. Who were there?—I do not know the gentleman's name, but he is here.

1361. Did he make a speech?—He asked us to collect the fishermen, and he asked me in particular, as I was the oldest fisherman there, to collect the fishermen together to see what we knew about it.

1362. After that I hope he behaved handsomely to you?—We had several pots of half and half.

1363. After having had these pots of half and half did he address you on the subject?—Yes.

1864. He told you what he wanted you to do, to find fault with the sewage?—Yes.

1365. Did he ask you how far you could help him?—Yes, he did so.

1366. He asked you if you could say the fish had gone out of the reach?—Yes, he did.

1367. He asked you if you could say that you had seen the sewage run down the Reach?—Yes.

1368. And kill all the fish?—Yes.

1369. You were all ready by the end of the meeting to come and give evidence for him?—We were quite ready.

1370. And parted very good friends?—I hope so.

1371. By the bye you said you have seen the sewage coming out upon the flood?—Yes, of course I have 20 or 100 times.

1372. At what time of the tide have you seen the sewage coming out upon the flood?—It has never left off at all from the ebb tide till they were compelled.

1373. The whole flood?—No, from the ebb tide, when they have sufficient room to begin on the ebb, they never left off till the flood tide stopped them, that is until it came against the mouth of the sewer, it was continually running.

1374. All through the flood?—As far as they could till about two hours before high water.

1375. (*Chairman.*) You mean to say they were discharging the whole of the ebb and the whole of the flood, except two hours before high water?—They could not commence upon the high water but when they had sufficient room, and so keep on gradually going.

1376. How early upon the ebb have you seen the sewage discharged, how soon after high water?—That is depending upon the flow of the tide. Sometimes a tide will flow 24 feet and sometimes 18 feet.

1377. What is the earliest you have seen after high water?—It might be 2½ hours.

1378. And you say they discharge the whole of the rest of the ebb?—Yes.

1379. And how much of the flood?—Till the tide had flowed up to the same mark as they began at.

1380. But I would ask how many hours would that be?—I do not know about the hours, we go by the tide.

1381. Would it flow till half flood?—Yes, that is about it.

1382. Are we to understand from you that you have seen the sewage flowing from half ebb to half flood?—Yes.

1383. (*Mr. Bidder.*) Until, as I understand you to say, the tide has so risen that it blocks the sewage back?—Yes, that is quite right.

1384. You mean they cannot let it flow out after it has risen to a certain height?—Yes.

1385. You mean to tell the Commission that that is a regular thing which happens every day?—Every day.

1386. And you have seen it hundreds of times?—I have.

1387. And you would say that as much sewage flows out upon the flood as upon the ebb?—Yes.

1388. Would you say more?—No, I do not say that.

1389. Have you many opportunities of seeing that?—Yes, I am continually, or I used to be out upon the river.

1390. You say there would be as much upon the flood as upon the ebb, or in fact rather more?—Yes.

1391. You have seen that this year daily?—Yes, I have.

1392. At both the outfalls?—Yes.

1393. Both Barking and Crossness?—Yes.

1394. The mud I think you tell us is quite a different colour in the river from what it used to be?—Yes to be sure it is.

1395. Used it to be a kind of a clear yellowy white, like sand?—It used to be mud with a worm in it, the red worm which is found in pure good mud, and the fish used to feed upon it.

1396. There are no worms in it now, are there?—No.

1397. Now what colour used it to be?—A kind of a brownish colour.

1398. Something like the wooden table just in front of you?—No, not that colour.

1399. This colour (*exhibiting whitey brown*)?—Yes, that was about the colour.

1400. Wherever you got it, whether from the bottom or the sides, or anywhere?—Yes.

1401. Not shiny at all?—No.

1402. Not greasy at all?—No.

1403. But rather sandy?—Yes.

1404. It would not stick to an anchor or a rope?—No.

1405. If you put your staff in it would not stick to it?—No.

1406. And it was quite sweet?—Yes.

1407. And now it is quite different?—Yes, it is 6 or 8 feet thick now.

1408. It is changed from the day when they opened the outfalls?—Yes, it is.

1409. The worms have all disappeared?—Yes.

1410. From that time?—Yes.

Re-examined by Mr. Morice.

1411. In fact there was, as you said just now, in former times a hard gravelly bottom?—Yes.

1412. Now there is nothing of the kind?—Now there is nothing of the kind.

1413. Now when this gentleman saw you at the "Golden Anchor," he took down what you had to say, did he not?—Yes, he did.

1414. Is this scum of the tide you told us about where the tide line is, between the tide and the slack water, or whereabouts is it?—That is caused by the point where the eddy tide runs; it comes out of the stream, and I consider it is partly purifying itself from the water which caused it to drift about.

1415. You tell us you cannot get fish where there is a lot of mud, would that depend upon what kind of mud it was.

(*Mr. Michael objected to the question.*)

1416. (*Mr. Morice.*) You say there are no worms in the mud now, and the mud is different from what it used to be?—It is quite different.

1417. Now with regard to the small amount of refuse which you say used to come from the factories, has that had any influence upon the fish in your opinion?—No, I should not say so, we did not find it so.

The witness withdrew.

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# FOURTH DAY.

## Wednesday, 15th November 1882.

PRESENT:

The Right Honourable LORD BRAMWELL, F.R.S., in the Chair.

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|---|---|
| Sir P. Benson Maxwell. | François de Chaumont, Esq., M.D., F.R.S. |
| Sir John Coode, Mem. Inst. C.E. | Thomas Stevenson, Esq., M.D. |
| Colonel C. B. Ewart, C.B., R.E. | James Abernethy, Esq., F.R.S.E., Mem. Inst. C.E. |
| Professor A. W. Williamson, F.R.S. | W. Pole, Esq., F.R.S., *Secretary.* |

Mr. Edwin Savery called in, and examined by Mr. Morice.



1418. I think you are the examining officer of the Customs at Erith?—I am.

1419. How long have you been at Erith?—About nine years.

1420. Has your duty taken you about the river in that locality?—I am daily on the water.

1421. What has been the state of the river during the time you have been there?—On some occasions it has been very bad, particularly in warm weather. Last year, when we had that very hot weather on two or three occasions, it was unbearable on the water. The moment that we got on to the pier my two men, who serve under me generally, used to say, "We know where we are, sir." We got the Thames aroma immediately we came off the village, but when we went afloat it was that bad on some occasions that, had it continued, I think it would have been almost impossible to have remained and done our duty. But if I may be allowed to observe, rather unfortunately for those who wish to do away with the sewage, the seasons for the last five or six years have been very much in favour of those who wish to continue the present state of things; we have had wind and rain and so on, and the result has been that we have not suffered as we did some years ago from the hot weather.

1422. Where do you find this smell worst?—When I am in Half-way Reach. The sewage comes out quite black.

*Mr. E. Savery.*

15 Nov. 1882.

1423. Can you notice the sewage in the river at all?—Unmistakably. You can see the line of demarcation so to speak, where the sewage runs and where the clear water runs. The water is hardly ever clear now, only sometimes a little after low water.

1424. How long have you known the river?—Nearly 40 years.

1425. Do you remember before the outfalls were made?—I do. When I was boarding foreign vessels coming from Gravesend, when I was in a subordinate position, when we got to Erith or even as high as Blackwall, the water was so clear that we used to drink it. Small vessels bound to sea did not go to the expense they go to now and have the water for which they had to pay, but they almost invariably dipped the river. It was the practice to dip at about half an hour before the flood, because then it is found that it meets the in-coming tide. It is driven back and you get the water fresher about half an hour after the flood than you do at any other period. They invariably took it to sea and drank it, and I have often drunk it.

1426. Do you know whether there has been any drinking of the water of recent years?—I do not think that anyone would be so unwise as to attempt it at present, and I am not aware of anyone attempting to drink it at present. It would not be drinkable.

1427. (*Chairman.*) Did the water ferment at all, not in the technical or chemical sense, but was there any perturbation in it?—There is great perturbation in it, but it appeared to me to be from air bubbles.

1428. Was that so when you used to drink it in the ship?—Not the slightest; nothing of the sort; it was almost like, in fact quite like, spring water.

1429. I have heard it said that even higher up the river, in the Pool, they took water out of the river and drank it; but there was a notion that it used to be what people call fermented?—There is a saying with the crews and captains of vessels (and it is a common notion, but I should think the correctness of it is doubtful,) that water should undergo one fermentation; that it is not good after you have gone to sea until it has undergone a change; but I should think that is open to very grave doubt.

1430. (*Mr. Morice.*) Do you know what is the state of the river above the outfalls now?—My duties do not take me above the outfalls, but only just at the top of the Reach where the outfall is.

1431. (*Chairman.*) But I suppose you must have noticed the water when the tide has been so low that the sewage which has been let out has gone beyond where you are?—I notice that from Erith and a little below Erith, and up to the outfall and a little below the outfall, we get that black dreadful sewage along the banks; and I have recently on some occasions gone and lifted some with a scull, or directed some of my men to do so, and it seemed to me to be pure black sewage. But I do not find that in Long Reach, or at Greenhithe, or at Grays; so that it would appear to me that there are some causes which are different below Erith. Why should it not accumulate, for instance, at the point off Purfleet and at Purfleet? There is no accumulation of this sewage there that I can see; but I found an enormous accumulation along the outfall right up that reach to the point at the top of Erith Reach and right away down Erith Reach. I noticed it more particularly when I knew that I had to come to give evidence before your Lordship, and I can see nothing of that sewage deposited on the banks below Purfleet.

1432. At very low tide the water at Gravesend is drinkable, is it not?—I should not like to drink it.

1433. It would be drinkable at Purfleet at very low tide, would it not?—I should imagine not.

1434. I mean but for the sewage?—We used to drink it, as I said.

1435. As low as Purfleet?—Yes, they used to dip it at Blackwall.

1436. But would it be drinkable lower down?—You are speaking with reference to its being brackish, I presume?

1437. Yes?—They would not dip it much below Purfleet, perhaps, because then you get it contaminated by brackish water.

1438. (*Mr. Morice.*) In the water in Erith Bight are there eddies?—There are; and I might observe that within the last few years just above Erith the vessels now, about two hours after ebb tide swing up as though it were flood tide, which is a thing that I never noticed in my nine years experience until these last three or four years. Some cause or other, which I should think must be the silting up of the river, causes those eddies, so that the vessels positively swing up. I used to have a difficulty in pulling up in the morning against the ebb but this sewage has assisted me in my duties, because we get a flood tide up. I have to visit the small vessels,—barges from Rochester and Faversham, and those places,—and just abreast of the outlet they bring up for the tide. It is a good shelter; being to some extent in a bight, they are out of the way of the steamers coming down; and I notice that within the last two or three years they have had to anchor a considerable distance out, and I have inquired of some of them why they do so. "Oh," they say, "we "cannot anchor where we used to, we should be "aground and in all sorts of difficulties;" and they all say that they are obliged to anchor at least 50 yards further out into the centre of the stream than they did a few years ago; and if that continues the River Thames will of course in course of time cease to be the River Thames.

1439. On the south shore above Erith do you know whether there are any deposits of mud?—Very large deposits, they do say 15 feet; but I notice that where the steamboats used to go in at certain times of the tide without difficulty, now they stir up the sewage and they get in with great difficulty.

1440. And continuing up the bight, past the Church Hole, has there been an increase of those banks during the last few years?—A great many feet I should say from my experience and observation. I have had no means of measuring; but from what I could see, that is so.

1441. Will you tell the Commission what those banks consist of?—I have tested them so far as the scull which we use will go down, and it appears to me to be solid black sewage. It is said by some that it is the breaking down of the banks, but I imagine that if it were the breaking down of the banks it would not smell as it does, because we have not only looked at it but we have smelt it, and it does not smell like the breaking down of the bank.

1442. Have you noticed it at low water?—I have.

1443. At low water on a hot day does it smell?—At low water on a hot day it smells dreadfully.

1444. Do you know the Causeway at Erith?—Yes.

1445. Do you know whether any alterations have been made in that causeway in recent years?—I understand that there have been two alterations, lengthening it something like 90 feet in consequence of the accumulation of the sewage, which some people say is the banks of the river, but I never saw the banks of the river like it for colour and smell.

1446. Will you tell the Commission how the sewage lies by the Causeway?—It lies, as it were, in heaps and piles, and it is unquestionably accumulating. It is black and smelling.

1447. Do you remember whether any fish used to to be caught in this part about Erith or in Half-way Reach?—Fish have been caught as long as I can remember up to within the last five or six years. When I was doing different duty to what I am now I used to board eel-scoots, and we used to come up to Erith, the water was as clear as crystal and the fish lived, and there was no complaint. I will not say since the sewage has been poured out at the outlet because it took place before that; but there is this about it, that the sewage which was so much annoyance to Westminster and to the noble lords and members of Parliament, that they could not sit in their chamber, they have relieved themselves of, and

have been kind enough to send down to Erith, and I am afraid that we at Erith have very much suffered. The eel-scoots had to leave Erith something like 18 or 20 years ago, but we can scarcely give the outfall credit or discredit for that, because so far as my recollection serves me, I think the outfalls have only existed about 16 or 17 years. They had to leave before the outfall was made. I attribute that to the state of the river.

1448. (*Chairman.*) The water had not got purified before it reached Erith?—Exactly.

1449. According to you the fish were poisoned then, and it is only a different mode of poisoning that is going on now?—Exactly so; but they should have taken it lower down.

1450. (*Mr. Bidder.*) You have told us about these eel-boats; do you know where the eel-boats stop now?—At Thames Haven. They went first to Greenhithe, but they found the water so impure at Greenhithe that they only remained there a year or two and then they went to Gravesend, and then the water was impure at Gravesend.

1451. (*Chairman.*) At what place down the river is the effect of the sewage imperceptible; you would not perceive it at Southend, I suppose?—I do not think you would.

1452. The volume of water is so great that it gets diffused?—That is so.

1453. How low down should you say that you are sensible of it?—My experience does not extend below Northfleet Hope; but I should say that at Northfleet Hope the sewage becomes so mixed with a large volume of water that you scarcely perceive it.

1454. Northfleet Hope is just above Gravesend, is it not?—Northfleet Hope is just above Gravesend.

1455. (*Mr. Morice.*) Then you would not think that there is much in Sea Reach?—I should say not, as far as I can judge.

1456. You were saying that these Dutch eel-boats have been driven down to Holy Haven, where they remain now?—Not merely the Dutch eel-boats, but all other fishing vessels. I can remember when there was a fleet of 50 fishing vessels about Greenhithe and Erith. They were shrimpers more particularly; I think that the flounders that they used to catch there were driven away earlier; I suppose the shrimps will live longer in bad water. The shrimping continued longer.

1457. There were, you say, a great many boats that used to fish close by there?—Yes, for flounders.

1458. Do you remember how many years ago they went away?—I should think not more than six or seven years ago.

1459. Do you know how far they go down now to fish?—I think they have to go down into Sea Reach, so far as I know; but my observation is not below Northfleet Hope.

1460. Do you know any illness that has been occasioned by this sewage?—There are vessels boarded that I have to supervise, and the officers have had to apply to me to get them medicine in consequence of their having diarrhœa on board, which they assumed was from the state of the water.

1461. In what parts of the river have you noticed these deposits of sewage beyond the portion either just above or below Erith?—I have not noticed any deposit of sewage but a very short distance below Erith.

1462. And the principal part, therefore, is in Erith Bight?—Erith Bight seems to be the great receptacle and there is an enormous increase of it. There is no doubt to anyone observing, as I have done daily, that the increase there is enormous from some cause.

1463. Do you know anything about some mooring buoys that were put down by the ballast wharf at Erith?—Yes, I have seen them, and I have seen that they do not lie in such deep water as they did formerly, and vessels which used to lie in there would certainly ground now.

1464. You were mentioning just now that you tried the depth of this mud with your scull; will you tell the Commission how far it went down?—The scull is only 12 feet long and we pushed it down some 5 or 6 feet, and I have no doubt, that had it been longer we could have gone deeper; but so far as we could ascertain, it seemed all to be of the same character, black sewage-smelling material, not such as you would get from the banks of the Thames.

Cross-examined by Mr. Bidder.

1465. I will ask you to be as definite as you can about one or two things. The first thing that you mentioned was that on certain occasions in hot weather the river smelt offensively; would you mind pointing out on the map at what part of the river you would experience that offensive smell?—I think I might say from Erith up to the top of Half-way Reach more particularly. I might say from half way down Erith Reach to the top of Half-way Reach.

1466. Above Erith?—No, below Erith.

1467. Now, perhaps you will tell me when?—The worst that I have smelt was last July, when we had that very hot weather. It was only for a day or two, until the hot weather ceased, but had the hot weather continued I will not say how bad it would have been.

1468. That is not so very long ago. Where did you smell it last July?—Off Erith.

1469. Was it very powerful?—Very.

1470. Have you ever experienced any offensive smell from any of the factories on either side of the river there?—I have done so from the atmosphere, but it did not appear to me to be from the water. You can tell generally whether a smell comes up from the water or whether it blows over your head. For instance, we get that smell in our houses at Erith; we do not get the smell of the Thames. All these smells from the factories we are favoured with in our dwelling-houses.

1471. But not the smell of the Thames?—No; because whenever you get the wind in a certain direction you get the smell of the glueworks and the paraffin-works. You can always tell the different smells according as the wind blows; but you do not get so much of the smell of the sewage on the land.

1472. You recognise the different smells?—Unfortunately I do; and so would you if you were there, I think.

1473. More or less savoury?—Very unsavoury.

1474. You also suggest to the Commission that there are very considerable accumulations, as I understand, which you say are accumulations of sewage, more especially in Erith Bight; am I right in that?—You are.

1475. And am I right in taking it as the result of your evidence that the only place where you recognise or suggest accumulations of sewage is in Erith Bight?—You are not quite correct there. I think I said in Half-way Reach as well.

1476. Do you mean opposite the Crossness Reservoir?—Just below that.

1477. On the south side?—On the south side.

1478. Those are the two places and the only places that you know?—To my knowledge.

1479. Let us have that definitely. On the south side in Half-way Reach, opposite and a little below the Crossness Outfall; and, secondly, in Erith Bight?—Yes.

1480. Have you taken any measures at different times to ascertain whether the mud in Erith Bight has been increasing?—It is, from observation. You cannot well make a mistake; you do not want to measure. You pass daily and you can see that a bank springs up like a little island; you know that it is there.

1481. How long is it since you began to perceive these accumulations in Erith Bight?—About four or five years ago they became perceptible.

1482. You could not perceive them before they became perceptible, you know?—Just so.

1483. Your business being on the river, to your knowledge, within recent years, have the Conservators of the Thames been carrying out considerable dredging

*Mr. E. Savery.*

15 Nov. 1882.

operations at that part of the river on the north side?—They have been continually.

1484. On the side of the river opposite to Erith Bight?—Yes, very considerably. They have removed several thousands of tons.

1485. They have removed a large projecting shoal known as Erith Rands, have they not?—Yes.

1486. And they have very greatly improved the channel of the river on that side?—It is improved, but I saw a vessel aground there not long ago. No one thought she would be aground.

1487. There is room for something more?—There is room for something more.

1488. Of course that has greatly deepened the water on the north side of the river?—It must have done so.

1489. And it has driven the stream more to that side?—It would do so undoubtedly.

1490. Are you surprised that that should have the result of making an eddy on the opposite side?—It might have that effect to some extent, but I do not think that it would have the effect of creating sewage.

1491. That I concede; but it might have the effect of accumulating good honest mud?—I grant you that, but not sewage.

1492. That takes me to my next point. Upon what ground do you say that the material of these banks is sewage and not river mud?—I have not analyzed it, although I might do that; but I have sufficient perception to know the difference between sewage and the sand off a bank. The delivery of thousands of tons of what you may call river mud happens o come under my notice. The whole of the cement t at is made on the River Thames is made from river mud and river deposit up at White's, at Greenhithe. They manufacture cement: in fact they are the largest cement manufacturers in the world, and all the river mud is brought from Rochester to Greenhithe which would be of the same character as this silting up would be if it were from the breaking down of the banks of the river. But I do not see anything at all corresponding with this river mud, thousands of tons of which are landed there every year.

1493. Leaving the cement mud at Greenhithe, what are the particular characteristics in this Erith mud that lead you to say that in your judgment it is sewage?—Its smell, colour, and general appearance.

1494. What colour is it?—Black.

1495. Turning brown on exposure?—No, remaining black as far as my experience goes. You can see it for yourself there; it is black on the surface at all times.

1496. Is it within your knowledge that the town of Erith discharges its sewage by open sewers at that very point into the river?—It is, and it is also, if I may so say, within my knowledge that they did so before this enormous silting took place.

1497. But, however, it is the fact?—It is the fact.

1498. How many sewers discharge in that Erith Bight?—I am only aware of one. I might mention that a great part of the sewage of Erith is put into cesspools and not into sewers. I have reason to believe that it is only the leading part of the place that is drained by sewerage.

1499. I will not discuss with you what portion of the town sewage it is, but it is the fact?—Still I think it is only fair to know what the whole of a large place like Erith does with its sewage.

1500. Still it is the fact that one or more sewers discharge into that Erith Bight; one to your knowledge?—Yes.

1501. Is that close to the Causeway?—No.

1502. Which is the one that you know?—The one that I know is below the pier. I do not think there is any other.

1503. Are you aware that there is also a sewer discharging at the Causeway?—I am not aware. I have never noticed it.

Re-examined by Mr. Morice.

1504. Do you know whether or not there are a large number of cesspools in the parish of Erith?—I always understood so; not from actual knowledge. I have some property there.

1505. Is not this sewer that you have been asked about, below Erith, near the ironworks?—It is only about a foot in diameter. The quantity that that could discharge would be a mere bagatelle to what we see.

1506. With regard to the mud that you have been talking about, you say that you know it from the smell and colour; does it leave any stain?—It stains the water.

1507. Does it stain anything that is put into it?—I have never tried that. The water that is about it is all black.

1508. And remains black?—And remains black.

1509. The factories that you have been asked about above Erith, you say have different smells which you can distinguish?—Yes.

1510. Have you any doubt about the smells from them being different from this sewage smell.

1510*a*. (*Chairman.*) It is manifest that there are other smells and that the witness can distinguish amongst them.

1511. (*Mr. Morice to the witness.*) I understand you to say that this sewage deposit is all from the south side of Half-way Reach down to Erith?—That is so; below Erith down towards the point. I do not notice it in Long Reach, but that might be due in some measure to the shoot of the tide through Long Reach. In Long Reach there is not much position for it to accumulate, but I do not see that it accumulates at Greenhithe where it might accumulate, because Greenhithe is quite in a bight and Long Reach is a straight reach.

Examined by the Commission.

1512. (*Chairman.*) Can you give us any further information which you think will assist us in this inquiry that we have to make?—I am of opinion that if this state of things goes on for any length of time, eventually you will lose the River Thames; that it must naturally silt up the river.

1513. I do not know that we can take your opinion as to what the consequences will be, because you are not an expert; but can you give us any information as to anything that you know or have seen or smelt, in addition to what you have already told us?—No, not in addition to that. I have been asked whether I thought the factories had the effect of killing the fish, and I have said, Why do they not kill the fish in the Tyne? You have more factories along the banks of the Tyne, and they do not kill the fish there. Fish is abundant in the Tyne, showing that it is the enormous amount of sewage that kills the fish and not the chemical works.

1514. Are fish abundant in the Tyne?—So I am told.

1515. You do not ever hear Newcastle salmon cried now, do you, though you used to?—Perhaps not.

1516. (*Professor Williamson.*) There is one point on which, perhaps, you will be so good as to give some further particulars to the Commission. You said, I think, that the deposit which is collected from the bed of the river for the purpose of making cement is always of one kind?—Yes, it is of a lightish colour.

1517. Do you mean by that that every deposit which you could collect is of that kind, or that they only collect that which is of a particular sort; are there not some banks of sand and others which have more of clay in their nature; are there not varieties in the composition and properties of the material which you find deposited in the Thames?—Quite so; but in all my experience of the deposits, I have never seen any deposit that looks and smells like that which you get at Erith.

1518. With regard to this particular deposit at Erith, did you say that your oar sinks into it, and that it is softer than the other?—Quite so. The other

deposit goes on gradually, and the clay accumulates and it eventually gets turned into stone, but that of course is the work of ages. But this sewage would be soft, and if you had a probe long enough you could probe the 15 feet which they say is the depth of it.

1519. And there is no other deposit so soft?—There is no other deposit so soft, it is saturated so thoroughly with water. But in the case of the clay the water does not seem to saturate it so much.

The witness withdrew.

Mr. Joseph Hathaway called in and examined by Mr. Morice.

1520. Do you live at East Greenwich?—Yes.

1521. How long have you been on the river Thames?—Fifty years.

1522. What have you been doing?—Fishing, and in the Metropolitan Thames Police.

1523. How long have you known the river for fishing?—I have known it for fishing for 50 years.

1524. During this time what was about the best part of the river for fishing?—The best part of the river at this time of the year, in November, is from Blackwall, and Erith, and Greenhithe.

1525. Which do you consider the best reach in the river?—Erith Reach.

1526. What fish could you catch there?—Flounders, eels, smelts, shrimps, and shad at times.

1527. Were there many fishing boats that used to fish there?—About 25 or 30; sometimes more and sometimes less.

1528. What is the state of things now with regard to fishing?—There are no fish to be caught from Greenwich. You can get no fish this side of Gravesend; nothing nearer than the Lower Hope, which is below Gravesend.

1529. (*Chairman.*) Between Greenwich and Gravesend there are no fish?—Between Greenwich and Gravesend there are no fish.

1530. (*Mr. Morice.*) When did you begin to find the fish gone away?—I should think the first of the fish decreasing in this river is about 16 years ago, from 1865 to 1866.

1531. What had the state of the river been before that time?—The water in this river was in a beautiful state; you could dip a pot overboard and drink the water.

1532. What part could you take the water from?—From any part you liked, in any reach you felt disposed; but now it is poison.

1533. Do you know whether it was commonly the case that the water was taken for drinking purposes?—I have done it myself, and I have seen ships, when they have been going away to Greenland, take the water in at Deptford, and water the ships from there.

1534. (*Chairman.*) How high up the river did your experience extend?—Up as far as Deptford.

1535. You used to fish up as far as Deptford?—Yes, and catch bushels, tons, of flounders, and eels, and whitebait, and shrimps. We used to catch whitebait off the "Trafalgar" and the "Ship" taverns, in front of the premises, and take them ashore as they wanted them; and now there is nothing to be seen.

1536. (*Sir J. Coode.*) What is the furthest point up the river at which you can catch whitebait?—The furthest point at which you can catch whitebait is the Lower Hope, Southend, Sheerness, and Queenborough.

1537. (*Mr. Morice.*) How long ago is it since you could catch whitebait a little higher up, say in Erith Reach or in Halfway Reach?—No whitebait, to my knowledge, have been caught in Erith Reach or Halfway Reach for, I should say, 14 years at least; it may be a little over.

1538. In fishing below Gravesend can you bring the fish up the river to market?—You must take them out of the water. The water is good below Gravesend, but as soon as you come above Gravesend with flounders and eels you have to take them out of the water until you get past the sewage water if you want to bring them to Billingsgate alive.

1539. What do you mean by taking them out of the water?—You have got a net on an iron hook and you sweep the fish out from the well and place them on the boat's deck, on the boat's flooring, and they will live there when they have not this poisonous water, until you get above where the sewage water reaches, and then you can put them into the well again.

1540. You mean that they will live better on the deck of the boat than in this poisonous water, until you get past it?—They will do so.

1541. (*Sir J. Coode.*) Do you, as a matter of practice, take them out of the water and then put them in again?—Yes, you can do that; or you can take out the flounders or eels, and they will live until you get above Gravesend, if the weather is cool, until you get to Billingsgate Market.

1542. But do you put them in again when you get above what you consider the sewage point?—Yes.

1543. (*Mr. Abernethy.*) How far up the river do you consider the sewage point?—Up above Greenwich.

1544. (*Chairman.*) What are you now, a fisherman?—I am not following that pursuit now. I did follow it; but I was an inspector in the Thames Division of Police. I have been up and down the river at all times—night and day and all.

1545. And what are you now?—I am going up with barges now with Mr. Henley, of North Woolwich.

1546. You said in answer to a previous question that you now take the fish out of the water; you mean that the fishermen do so?—I understood the question to be, "Do they now?" and not to have reference to myself.

1547. (*Mr. Morice.*) Does the time at which you put the fish back again into the wells depend upon the time of the tide?—It will be on the flood-tide when you put them in.

1548. (*Chairman.*) You say that you do not do it yourself; but I suppose you know that the fishermen do it?—Yes.

1549. Does the well communicate with the exterior water?—Yes, there are holes in the boat's bottom which allow the water to come from the river into the well.

1550. And do they return the fish into the well?—Yes.

1551. At what point do they do that?—They do that up above Greenwich.

1552. (*Mr. Morice.*) And then, on the flood-tide, the water is good enough to admit of their putting them back again?—After you get above Greenwich it is.

1553. Can you tell us the state of the river banks from, say, Barking?—Yes.

1554. Has there been any deposit of mud there in recent years?—At Barking do you mean?

1555. Or on the banks at either side?—Yes, there is now, and it has greatly increased.

1556. Whereabouts is it chiefly deposited?—It is deposited against the northern outfall down at Barking Creek, and from Crossness in Half-way Reach and Erith. The Causeway at Erith, where we used to make our boats fast to a ring, has been heightened three or four times, and now it will have to be heightened again. At Jenningtree Point, where 20 or 30 barges used to get sand, they cannot get sand at all, or when they do get it they have to rake the black, stinking mud on it.

1557. You know the Causeway at Erith?—I do. We used to make our boats fast to a ring there.

1558. Can you do so now?—No; it is overflowing with mud. There are five or six feet of mud there now—nasty, stinking, black sewer stuff. You cannot call it mud; it is not mud.

1559. How far did it go from the bank?—It is from the bank right away down to low water.

1560. Do you know the fact of the Causeway being

*Mr. J. Hathaway.*

15 Nov. 1882.

lengthened?—The Causeway has been lengthened, and it has been raised three or four times.

1561. Did the water about the part you have been mentioning, Half-way Reach and Erith Reach, have any effect upon your nets?—When the water was clear in the river our fishing nets would last about twice as long as they would last now, for the water now completely rots them, and you cannot get them clean; but when you take them out and wash them they stink so that you can hardly bear them in the boat.

1562. (*Professor Williamson.*) I thought you did not fish any more now?—We did do so until such time as the sewage water came down, and then it drove all the fish away, and you could not get the nets clean, and they would rot in one third the time that they would before.

1563. (*Chairman.*) When did you leave off fishing yourself?—I left off fishing myself in 1851; but I have been on the water side ever since. I have been in the Thames Police going up and down.

1564. Have you ever experienced this inconvenience in the case of the nets that you used?—Not when I was fishing. I am speaking of the nets of other people. I have seen them myself.

1565. (*Mr. Morice.*) You have been about the water side ever since?—Yes, and on it. I was Inspector of the Thames Police.

1566. (*Sir J. Coode.*) When you were Inspector, what was the extent of your district up and down the river?—From Blackwall to Deptford Creek, and down as far as I felt disposed to go. I have been down to Greenhithe or Gravesend.

1567. (*Mr. Morice.*) I believe as Inspector of Thames Police it was your duty to be afloat?—It was, night and day.

1568. Therefore you have seen and smelt a good deal of the river in consequence?—I have.

Cross-examined by Mr. Bidder.

1569. As far as fishing yourself goes, you have had nothing to do with it for 30 years?—No, but I have been up and down and alongside of the boats when they have been fishing at Greenwich and at Erith and at Greenhithe.

1570. I understand that there are no fish to catch above Gravesend?—There are not now.

1571. Then I presume there is not anybody fishing for them?—No; they cannot get any; nothing nearer than the Lower Hope.

1572. How long is it since fishing has been given up above Greenhithe, as far as your observation goes?—I should think about 14 years.

1573. So that practically I may say that there has been no putting of nets into the river above Greenhithe since the sewers were opened?—Yes, they have put in the nets, but with no effect; they have not been able to catch any fish. They found that as the water was so bad in the river they had to go further down for them.

1574. With reference to the deposit you have spoken of at Erith by the Causeway, do you know when that Causeway was built?—No, I do not. Do you mean the original one?

1575. It was lengthened some few years ago, was it not?—Yes, it has been lengthened and raised; but I did not take the dates of course.

1576. When was it lengthened?—That I cannot speak to.

1577. I need not ask you whether you know about the dredging operations. I suppose you have no particular information as to that.

1578. (*Chairman.*) You have had that from one witness, and I think your own observation is a tolerably plain one, that those operations would have a tendency to create an eddy.

1579. (*Mr. Bidder to the witness.*) You say that fish cannot be brought up in the wells of boats; are you aware that the Dutch eel-boats come up to the Pool with eels in their wells now?—They do not. The Dutch eel-scoots used to lie at one time at Erith, but now they are obliged to lie at Holy Haven, and they are brought up in trunks.

1580. Will you undertake to tell the Commission that it is not the fact that Dutch eel-boats come up to the Pool with live eels in their wells?—To the best of my knowledge they do not. They come up to sell the eels which they bring from Holland over here, but not in the wells.

1581. You reside at Greenwich; were you one of the gentlemen who met at the "Golden Anchor"?—I was at the "Golden Anchor" some time ago.

1582. A gentleman came down and a certain number of pots of porter were distributed amongst the fishermen. Do you know Mr. Cobb, who was a witness here?—I do.

1583. Were you one of the gentlemen invited by him to come to the "Golden Anchor"?—I was at the "Golden Anchor."

1584. Where there was a gentleman who gave you all pots of porter?—Not many pots of porter.

1585. And who asked you to say what you could say against the sewage?—Not against it. He asked me, "Are you a fisherman?" and I said, "Yes, I have "been on the water for 50 years." He says, "I want "you to state what you know about the fishing and "what you have seen: speak truly and honestly on "both sides."

1586. I daresay your account will not differ from Mr. Cobb's. He had several pots of half-and-half. He was asked, "Did he tell you he wanted you to find "fault with the sewage?—(*A.*) Yes. (*Q.*) Did he "ask you how far you could help him?—(*A.*) Yes, "he did so. (*Q.*) He asked you if you could say the "fish had gone out of the Reach?—(*A.*) Yes he did. "(*Q.*) He asked you if you could say that you had "seen the sewage run down the Reach?—(*A.*) Yes. "(*Q.*) And kill all the fish?—(*A.*) Yes." Is that about what took place?—Mr. Cobb was there before I was, so I cannot say.

1587. He was commissioned to invite the rest of you?—No, he was not.

1588. I see he added that you all parted very good friends?—Yes, we parted very good friends.

Examined by the Commission.

1589. (*Sir B. Maxwell.*) You were a fisherman down to 1851?—I was a fisherman down to 1851.

1590. Then you went into the Thames Police?—Yes.

1591. How long were you in the Thames Police?—I was in the Thames Police for 21 years. I left in 1871.

1592. Then from 1871 down to the present time how have you been employed?—I was on Mr. Henley's Telegraph Works at North Woolwich, going backwards and forwards on the barges.

1593. Does that keep you on the river daily—Yes, and at night as well.

1594. (*Chairman.*) Where do you live now?—At No. 44, Marlborough Street, East Greenwich.

1595. This condition of the Thames of which you complain does not trouble you where you dwell?—No.

1596. In what part of the Thames do you work now?—From North Woolwich up to the East India Docks, the West India Docks, and Milwall Dock with barges.

1597. Do you smell the sewage?—Yes.

1598. How high up the river do you detect it?—Up as far as Blackwall Reach, and sometimes in Greenwich Reach.

1599. In what states of the tide do you detect it so high up as that?—On the spring tides, when the tides are running heavy, then it comes further up the river; but in our police galley, when they were letting it out in Half-way Reach, and likewise at the northern outfall, and especially in the summer time, there used to come such a faint, nasty, stinking smell that you could hardly bear it, and it turned you sick.

1600. That was below North Woolwich?—Yes, that was at the northern outfall.

1601. It is not much trouble to you now, because it is only occasionally that you smell it?—Yes, only occasionally. It was our duty in the police galleys, if we saw offensive matter, to summon the parties.

1602. It is only on spring tides, as I understand, that you smell it now when you are at work?—Only at spring tides, and then we smell it at Blackwall and Greenwich Reach.

*Mr. J. Hathaway.*

15 Nov. 1882.

The witness withdrew.

Mr. James William Farthing called in and examined by Mr. Morice.

*Mr. J. W. Farthing.*

1603. You live at East Greenwich?—Yes.

1604. How long have you known the river Thames?—62 years; and I have been on the water 62 years.

1605. Do you remember the sewage outfalls being opened?—I reckon it is from 16 to 17 years ago.

1606. What are you?—I am a Greenwich waterman.

1607. What was the state of the river before the outfalls were opened?—Very good; ships of all kinds used to get their water for drinking there, to take to sea.

1608. At what part did they get it?—Between Limehouse and Woolwich; but mostly about Greenwich, if they could get there.

1609. (*Chairman.*) I do not notice that there is any cross-examination as to that?

1610. (*Mr. Bidder.*) I did intend to ask one question about it.

1611. (*Chairman.*) There is no doubt that at one time the Thames water was drinkable at London Bridge, because there were waterworks there.

1612. (*Mr. Bidder.*) I have always understood, as your Lordship said, that it fermented, and, after that, it was considered the finest water to take to sea.

1613. (*Chairman.*) I suppose it may be admitted that that is not the case now?

1614. (*Mr. Bidder.*) That is not the case now.

1615. (*Witness.*) It is not.

1616. (*Chairman*) He might give us, if he can, the date when that ceased to be the case.

1617. (*Mr. Bidder.*) I am told that ships are not now in the habit of filling their water casks from the river.

1618. (*Witness.*) No; it would be poison.

1619. (*Mr. Morice.*) When did the ships, to your knowledge, cease taking in water from the river?—I should say about 14 years ago. I recollect the fishing smacks belonging to Greenwich about 14 years ago, that is about the last time that they used the water for taking to sea, because I worked for a gentleman of the name of Mr. Roberts, who was a smack owner, and I was employed by him over 22 years, and I used to take his fish from Gravesend to Billingsgate Market.

1620. Then 14 years ago you remember their taking water for drinking purposes?—It might be 15; I cannot exactly say.

1621. Since that time you do not know that they have done so?—No; the water has been getting worse and worse since that.

1622. During the last 8 or 10 years has it been getting very much worse?—Every year it gets worse. The eel scoots used to lie just above Erith, in Erith Gut, in the Bight, and there eels would live well. In a couple of years, after the sewers commenced, they had to shift to Gravesend, and the eels would not live there; and then they had to go down to Holy Haven and lie in Holy Haven harbour with their eels.

1623. Are eels easily killed; are they hard fish to kill?—They do not like bad water. They will live longer out of water than they will in bad water.

1624. You say that the river has got worse; in what way has it got worse?—On account of the sewers.

1625. How do you find that the river has got worse?—I will tell you. I worked for these smacks over 22 years, and they used to bring their fish to Greenwich before they swept them out. And now the fish will not live at Gravesend; the water is not so good now at Gravesend as it used to be at Greenwich at that time 18 or 20 years ago.

1626. How were you employed on the river; did you have anything to do with this fish business?—Yes.

1627. What did you do?—The smacks used to go to the North Sea; and sometimes they would bring 50, 60, or 70 score of cod up to Gravesend and market a certain quantity away every day until they were out; and the last day the vessel would go home up to Greenwich with the fish in them, and they would live till they got to Greenwich. That was before the sewers commenced.

1628. What did you do in it?—I and my mate had a boat; it was always a two-handed job, and we used to take a certain quantity, such as 8, 10, or 12 score while the vessel was lying at Gravesend up to Billingsgate Market every day till the fish was gone, according to what the vessel had.

1629. Since the sewers were opened has this been altered?—They cannot come in the river at all; at least the fish will not live in the river at all. They will not live out of Sea Reach. In the Lower Hope they begin to turn up.

1630. Then do the boats stop with the fish at the Lower Hope?—They do not come up here now. They were forced to keep down there. They go to Harwich or anywhere according as the wind is, where they can fetch. They go into Lowestoft, Harwich, Grimsby, Yarmouth, anywhere according to the wind, and they send them up by rail.

1631. Have you left off fishing?—I am a waterman. At the first commencement I went to sea with my father when I was 15 years old, until I was old enough to be bound apprentice to the water; and I have been at work on the water now for 62 years since I was apprenticed.

1632. (*Sir B. Maxwell.*) Not as a fisherman?—No; as a waterman. In the first place before I used to work for these fishermen, I used to go up and down as pilot with shipping, with vessels of all kinds. That was before there was any steam.

1633. (*Mr. Morice.*) Being on the water, have you noticed anything with regard to your ropes in the water so far as their smelling is concerned?—Yes, I should say that if you came to let go an anchor it was like hauling up so much grease, and you would hardly make out whether the anchor was iron or a lump of muck.

1634. When the anchor came up, what was there on it?—A kind of slime, not mud, a mixture like; I cannot tell you what it was—a mixture of mud and slime more like grease than anything else.

1635. (*Chairman.*) That is the case now?—Yes.

1636. (*Mr. Morice.*) Was there any smell to it?—Beastly. All the way up and down along the south shore from the sewers right down below Erith, in rowing up, if you take and shove your scull in and stir it up you will find that it is a mixture of mud and slime.

1637. Do you know the whole of the river all the way down to Gravesend?—I should think I do.

1638. Have you noticed whether there have been any mud banks formed on either side of the river?—I think there is a deal less water than there used to be.

1639. Do you know whether there has been any mud at all formed on the way down the river?——

1640. (*Chairman.*) Is this the same mud bank in the Erith Bight?

1641. (*Mr. Morice.*) Partly, my Lord.

1642. (*Chairman.*) We have it conceded by the other side that that is attributed to another cause.

1643. (*Mr. Bidder.*) My learned friend is perhaps not aware, but your Lordship or some of the Commission will probably be aware, that that question was the subject of a preceding arbitration which was exhaustively gone into.

1644. (*Chairman.*) My impression of that inquiry was that the award was that there was as much water way as ever; but I do not think that they said that the banks were in the same place, did they?

*Mr. J. W. Farthing.*

15 Nov. 1882.

1645. (*Mr. Bidder.*) No, my Lord. Of course the Commission is in no way bound or concluded by the decision of that arbitration; but still it may save a little time if I tell you that the question there was this: that under one of the sections of the Metropolitan Board Acts the Conservators had a right to take the Metropolitan Board to arbitration if they believed that the sewers had in any way interfered with the bed of the river by causing silting up. They did accordingly make the charge against the Metropolitan Board that the results of their outfalls was to produce accumulations of matter. For that purpose it did not matter whether this was sewage matter or pure sand, but it was alleged that it was producing accumulations at different parts of the river. When we came before the arbitrators, they confined themselves ultimately to those that have been mentioned to-day, one at the Barking outfall, one off the Crossness outfall, another that you have not heard of on the north side, and the one in Erith Bight which they did not rest so much upon. They rather admitted that they must give that up. The result of it was that the whole of that arbitration was fought upon the one question whether these banks were caused by the sewage outfalls or not. That question the arbitrators determined in our favour; they determined that they were not.

1646. (*Mr. Morice.*) It was a question, then, of the navigation of the river, and not a question of the deposit of sewage, which is quite another matter.

1647. (*Mr. Abernethy.*) With all due deference to the learned counsel, I think what was proved was that the navigable channels had not been materially interfered with.

1648. (*Chairman.*) Supposing that the bank was not what you may call caused by the sewage, and that there would have been a bank without the sewage, still if it is a bank of sewage deposit it is obviously a matter that we must inquire into.

1649. (*Mr. Bidder.*) Of course that arbitration had nothing to do with the question, supposing that the bank was produced by causes other than sewage, what the components of the bank were.

1650. (*Chairman.*) This arose out of a question which I asked Mr. Morice, whether he was going to examine this witness as to the existence of a bank, which it is conceded does exist. But what it is made of is another question, and how it was constituted is another question.

1651. (*Mr. Morice to the witness.*) Do you know the south shore along Half-way Reach down to Erith?—I do.

1652. Do you know whether there is any deposit of mud along that shore from Half-way Reach down to Erith Bight?—Yes, from the half-way house point, that is Crossness, down to Erith.

1653. (*Mr. Bidder.*) It was an admitted fact on the arbitration that there was a very large accumulation of mud opposite our Crossness outfall. The question as to what caused it is another matter.

1654. (*Mr. Morice.*) I mean to go further than that. (*To the witness.*) Do you know whether there has been any increase in the last few years of the banks of mud along that shore?—Yes, a good deal.

1655. Can you tell the Commission of what it is formed?—It is a nasty greasy soil. I cannot tell what to call it; it is not regular mud as it used to be, it is more like grease.

1656. You remember the bank along that shore; what sort of bank used it to be, say, 20 or 30 years ago?—What they called the saltings.

1657. And now you say it is not mud, but a slimy substance.

(*Mr. Bidder handed to the Commission a copy of the Report and Determination of the Arbitrators in the case referred to.*)

1658. (*Chairman.*) Does it not come to this, that there is a greater draught of water and that vessels of greater tonnage can come up, but that the channel is to a certain extent narrowed by the formation of banks, so that the ships cannot make as long boards and tacks as they used to make; that the dredging by the Conservators has mainly occasioned the foundation of these banks, but that no doubt they are to some extent increased in size by the sewage.

1659. (*Mr. Bidder.*) I do not think they say that they are increased in size.

1660. (*Chairman.*) They are said to be "partly "from denudation of the river bed, partly from sewers "in districts outside the Metropolitan area, and partly "from sewers in the Metropolitan area. The pro- "portion contributed from this latter source is small "as compared with the total amount of suspended "matter in the whole volume of tidal water which "flows past the outfalls on every tide. Whilst, there- "fore, the sewage from the Metropolitan outfalls may "have contributed to their contents, the three banks "cannot be said, in the sense of the Act of 1870, to "have arisen from the flow of sewage at the outfalls; "and we are therefore of opinion that the Metro- "politan Board of Works should not be called on to "remove or contribute any portion of the expense of "removing the three banks, or any of them."

1661. (*Mr. Morice to the witness.*) Will you tell the Commission why you say that this soil is not mud?—It is not mud; you cannot call it mud.

1662. Why do you think it is not mud?—Because it is of a slimy nature.

1663. What colour is it?—All manner of colours, yellow and black.

1664. (*Mr. Bidder.*) I do not know whether I might suggest to my learned friend that we had in that case, and probably shall have again, a large body of scientific evidence. Surely the chemical constitution of this mud is not a question for this witness.

1665. (*Chairman.*) What can this witness tell us more than he knows, that the bank is there, and that in his judgment it is mainly made up of sewage matter?

1666. (*Mr. Morice.*) Quite so, my lord, I am not asking him any further than that, except that from his knowledge he knows that it is not ordinary mud.

1667. (*Witness.*) It is not what it used to be 20 years ago; and not only that, I know that in Half-way Reach where there used to be 15 or 16 feet of water there are not above 10 feet now.

Cross-examined by Mr. Bidder.

1668. I am not going to ask you about the mud, but about one other matter. You spoke about the condition of the river when you raised an anchor. How long is it since you were on the river working as a waterman?—62 years from the time I was first bound.

1669. Are you at work now as a waterman?—Yes.

1670. Every day on the river?—Not exactly every day. All that I do now is, I may say, Jack's last push; that is doing a little sculling; but I have had charge of craft of all descriptions.

1671. When were you last down at Erith?—About a month ago I went down with a vessel to Gravesend, but still I did not stop there, I went right by Erith.

1672. You have told the Commission a good deal about the condition of the water getting more unsuitable for drinking and for fish; is that what you refer to when you speak of the river getting worse?—Yes. In the summer you can hardly bear yourself, for the smell of the water at Greenwich at high-water time when you have two days warm and calm.

Examined by the Commission.

1673. (*Chairman.*) Where do you work now?—At Greenwich.

1674. Upwards or downwards, or across; are you a waterman for passengers?—Yes, now. Formerly I used to go up and down with shipping, but now the old people are no go. I do a little, what I can, in sculling. I take Mr. Yarrow's people backwards and forwards: he builds these torpedo boats. That is all I do now. I do not go much down now.

1675. You do not very often go to where the smell is?—I work for a man who is now the master and owner of a vessel, and who was one of my former master's apprentices, and I always go up and down with him, but that is the only time I go down the river now.

1676. You have no particular interest in this matter; this smell does not trouble you much?—No, only at high water in summer time, and then it stinks awful.

1677. Even up at Greenwich?—Even up at Greenwich.

1678. At what state of the tides; spring or neap?—Sometimes at spring tides, if the weather is warm. I will tell you the reason of that. About 20 fathoms from the south shore where the outfalls are, it is all the heavy tide on the ebb, about the last quarter ebb. The sewer still keeps pumping this stuff out. That does not go down, it all comes out and settles. Then when the flood comes where that eddy is, the flood runs hard and away it goes up with the flood; it does not go down after the last quarter ebb; it does not go any further down, it comes out and settles. And then when the flood comes up that which remains, which has not settled, comes.

*Mr. J. W. Farthing.*

15 Nov. 1882.

The witness withdrew.

Mr. James Clarke called in and examined by Mr. Morice.

1679–80. I believe you were born at Erith?—Yes.

1681. And you are now a boot-maker?—Yes.

1682. And you have been a watchman at Price's Oil Works along the banks of the river?—Yes.

1683. How long do you remember the river?—I can remember the river from three years of age, and I am in my fifty-eighth year.

1684. That is over 50 years. Do you remember the state of the river before the outfalls were opened?—Yes; it was pure.

1685. You say the river was pure before the outfalls were opened?—Yes, before the outfalls were opened.

1686. After that, did you notice any alteration in the river?—Yes. The river has been filling up the whole time, and if it was not for the Thames Conservancy dredgings, no ships of any heavy draught of water would be able to come up.

1687. You say that it has been filling up; whereabouts has it been filling up?—In different parts of the channel, both north and south.

1688. Have you ever bathed in the river?—Yes.

1689. How long ago?—In my younger days, up till I was about 20 years of age.

1690. Have you bathed in it lately?—No, it is not fit to bathe in.

1691. Was there ever any sand or firm walking on the banks of the river near Erith, years ago?—Yes; when I was about 16, from that up to 20, in my bathing time, you could walk from the lower ballast wharf to Jenningtree Point on hard dry sand, but you cannot find any now.

1692. What is there now?—It is all a black slimy mud up to your middle.

1693. Do you know the Causeway at Erith?—Yes.

1694. Has there been any alteration made in that?—Yes.

1695. (*Chairman.*) Have we not had that over and over again? Is it not conceded and not cross examined to?—We may take that for granted.

1696. (*Mr Morice to the witness.*) How long were you at Price's Factory as watchman?—Over nine years.

*Mr. J. Clarke.*

1697. How long ago was that?—I went there in 1864, the year after the gunpowder explosion in the marshes.

1698. During that time did you notice anything unpleasant about the river?—Yes; I have noticed it many times, and have gone home ill in the morning after leaving duty.

1699. What did you notice that was unpleasant?—An unpleasantness comes off the river similar to decayed animal matter. I had been at Price's about three years when an accident happened to me. I fell overboard, and I was taken home from there very seriously ill, and a medical man now deceased told me——

(*Mr. Bidder objected to this evidence.*)

1700. (*Chairman.*) We could not take that.

1701. (*Mr. Morice to the witness.*) You were ill at any rate?—Yes.

1702. During the time you were at Price's you say the river was unpleasant. Was it so often?—I would say it was most unpleasant during the hottest part of the summer.

1703. (*Chairman.*) Did you fall into the water which you say is foul water?—Yes.

1704. Can you tell us what were your sensations. Did it have any unpleasant effect on you?—Yes; I went home in the morning, when going off duty ill, and I stopped at home for about three days through taking in a large quantity of water.

1705. You could not help swallowing some of it?—No; because I went under one barge and came up at the tail part of it.

1706. Then you felt the bad effects of swallowing the water?—Yes, certainly I did.

1707. Have you ever felt any ill effects from it since?—Not from the water, because I have never been in the water since, but I have from the smell being alongside of the river.

Cross-examined by Mr. Bidder.

1708. Where was it that you fell overboard; was it in the river itself?—At Mr. Price's works, alongside the wharf, near upon high water.

1709. Were you some time under water?—I went in at one end of the barge and came out at the other.

1710. Then you were in a very exhausted state when you came out?—Yes.

1711. I daresay you had swallowed a good deal of water?—Yes, I had.

1712. Were you conscious when they got you out?—I was conscious, and I came out and sat on the bank.

1713. And you felt very bad afterwards?—Yes.

1714. And you had two or three days at home?—Yes.

1715. What do they make at Price's Factory?—They are tar distillers, turpentine distillers, oil refiners, fat refiners. I do not think you could call them makers of any article; they are refiners and purifiers.

1716. Are there any unpleasant smells in connexion with the manufacture of those various things?—No, I cannot say that there are, without it is smoke, because there are enough fumes of acid about to kill anything.

1717. Have you ever heard of the people of Erith complaining of the abominable smells that came from Price's Factory?—Well, I have oftentimes seen it in print.

1718. It is a matter of constant complaint in Erith, is it not?—I do not know whether they put it in on purpose to injure the plant or no; but oftentimes when the wind is in the east it will carry the smell inland.

1719. But there have been not only a good many notices in print, but the inspectors have been sent down several times to Price's works, have they not?—I do not know.

1720. You were employed as a watchman at Price's?—Yes.

1721. Since that, what have you been doing?—I was laid up about 15 months attending hospitals, and after that I came home. I was apprenticed to the boot trade.

*Mr. J. Clarke.*

15 Nov. 1882.

1722. For the last 10 or 12 years you have been employed in boot making?—No, only about three and a half years.

1723. Who asked you to come here?—Mr. Frederick Parish wrote to me to come.

1724. (*Mr. Morice.*) He is instructing me on behalf of the Local Board.

1725. (*Mr. Bidder to the witness.*) Is it a fact within your knowledge, that at Price's Factory, the refuse from the factory runs into a ditch?—Yes; but I believe that now, at the present time, it runs into pits. There was only water when I was there.

1726. When you were there, did the refuse run into a ditch?—Yes.

1727. And did that ditch run into the Thames?—It came in communication, I believe, with what they call a sewer ditch.

1728. And so got into the Thames?—Yes.

1729. (*Dr. Stevenson.*) Where is Price's Factory? Just below Jenningtree Point, about 200 yards from Jenningtree Point on the south side.

Re-examined by Mr. Morice.

1730. Do you know whether there used to be any sea-weed just above Erith?—Yes; I have used it as manure, and other people too, largely.

1731. How many years ago would that be?—That would be in about 1859.

1732. Have you been able to get any in the last 10 or 15 years?—No, not in large quantities. I very much doubt whether you would get half a ton, from the Half-way house to Greenhithe.

1733. Can you tell the Commission why you have not been able to get it.

1734. (*Chairman.*) Does it grow there now?—No, not now; it is dwindling away.

1735. (*Chairman.*) I thought that this sewage was a great promoter of the growth of vegetable matter.

1736. (*Mr. Morice to the witness.*) With regard to the factory smells you say that they are quite distinct from the sewage smells?—Certainly they are.

The witness withdrew.

*Mr. J. Thorne.*

Mr. John Thorne called in, examined by Mr. Morice.

1737. You live at Greenwich?—Yes.

1738. Have you been engaged in fishing in the river there?—Yes.

1739. For how many years?—I have been engaged, along with Mr. Cobb, 10 years.

1740. What are you now?—A waterman.

1741. Where do you ply?—We do not ply at all; we go down the river looking after our living amongst the small craft and shipping.

1742. Do you remember the sewage outfalls being opened in the river?—Yes.

1743. What was the state of the river before that time?—The state of the river before that time was that the water was very good, all up and down the river.

1744. Did people drink it at all?—Yes, I have drunk it many times. Likewise we used to always fill the water at Barking for the smacks.

1745. Since the outfalls have been opened, has there been any difference in the state of the river?—A deal.

1746. In what way?—The water is very bad and very black and very stinking.

1747. Has that been so more particularly in the last few years?—It has been so more particularly ever since the outlets have been opened.

1748. You used to be fishing on the river up to how many years ago?—I have left off now about nine years.

1749. What fish used you to catch in the river?—I was down in the Lower Hope catching whitebait, shrimps, flounders, eels, and all sorts of fish.

1750. Before the outfall was opened what was the best part of the river for fishing?—Somewhere about Erith, at Erith Rands.

1751. (*Chairman.*) That was your fishing ground?—Yes.

1752. I thought you said that you went to the Lower Hope?—That is lately.

1753. Formerly you used to fish at Erith?—Yes, that was before the outlet.

1754. (*Mr. Morice.*) Used there to be many fishing boats at Erith?—Yes, lots.

1755. How many at a time?—There used to be, I cannot say exactly how many, but I should say from 30 to 40 boats standing off, shrimp catching, whitebaiting, and one thing and another. They caught fish of all sorts and any sort.

1756. Was it a good fishing ground?—Very good indeed.

1757. When did you have to leave that fishing ground?—They have had to leave that fishing ground now, I should say, about from 15 to 16 years, as near as I can guess.

1758. What did you have to leave it for?—On account of the outlets of the sewers.

1759. Where did you go to after you left it?—We went down fishing at Grays, and Greenhithe, and Gravesend, and the Lower Hope, and all round.

1760. What is the highest part of the river towards Erith where you fish now?—The highest part that I have been fishing in, in the latter end of my fishing, was Gravesend Reach.

1761. What did you catch there?—Shrimps, whitebait, flounders, eels, and all sorts of little fish.

1762. How long is it since you used to fish at Greenhithe?—When we were last standing at Greenhithe was about from 12 to 13 years ago, for the bait.

1763. When you catch the fish down at Gravesend can you bring them up the river?—We can bring them up to a certain place and then take them out and spread them all over the boat and row up to Billingsgate with them.

1764. When you take them out and spread them over the boat, what is that for?—To keep them alive. They would not live in the water.

1765. Why?—Because the water is so bad.

1766. When do you put them in again?—If you want to put them in again you can put them in at what we call the Dutch eel-scoot pier off the Custom House.

1767. What effect does it have upon the fish, supposing that you do not take them out when you get into this bad water?—It kills them all. They would not live in the water a minute.

1768. (*Chairman.*) They die at once, do they?—Yes.

1769. (*Mr. Morice.*) You find that it is better to take them out?—Yes.

1770. (*Chairman.*) Did it seem what one may call a sudden death, or did they struggle first and then die?—They died directly, as soon as ever they got into the water. When you come into Half-way Reach, if you put the fish overboard you would see that they died directly.

1771. (*Mr. Morice.*) But did they jump about or do anything of that kind?—No.

1772. (*Chairman.*) They do not struggle at all?—We do not leave any in the wells to struggle, because when we are in good water we take them out.

1773. (*Sir B. Maxwell.*) You say you take them out at a certain place; where do you take them out?—We take the fish out at Gravesend.

1774. (*Mr. Morice.*) Then you say that you can put them in again when you get up to the Custom House?—You can at times: it is all according to the water. We have put them in and they have lived at the Custom House.

1775. Is there any smell from this water in the river?—It is very bad indeed in hot weather.

1776. Does it have any effect upon your nets when you put them in?—There is nothing but slime in our nets, but they do not put any in now. It is no good putting any gear over at all for fishing in the river from Woolwich to Greenhithe.

1777. And you have given it up for that reason?—Yes.

1778. Is there any difference in the colour of the mud in the river, so far as you have seen, in the last few years?—A deal. It is not mud, it is more like slime than mud.

1779. What is the colour of it?—Black, very black indeed.

1780. Is there any difference between that and the water in the River Medway?—Yes, a deal.

1781. What is that like?—That is clear.

1782. Are the water in the River Thames and the mud different from what they used to be?—A deal different.

Cross-examined by Mr. Bidder.

1783. I understand you to say that before the outfalls the condition of the river was very good, both up and down?—Yes, both up and down.

1784. How far up; up to London Bridge?—The water was good up to London Bridge, and above that.

1785. There were no complaints of it?—There were no complaints of it. At one time the water was bad. I think that was about 1852 or 1853. We had a plague with the water then.

1786. There was nothing to speak of in the condition of the river?—Nothing like it is now.

1787. There was nothing really objectionable in its condition?—Nothing at all.

1788. You never heard of any complaints of the condition of the river before the main drainage works were made?—I never did in my life.

1789. You, I understand, have not been a fisherman for the last 9 or 10 years?—I have not.

1790. You do not know anything about the Dutch eel-boats?—I do; and I have fetched the eels up to London out of them.

1791. Do you know whether they bring up eels in their wells?—They do not. They sweep out at Holy Haven mostly, and then they run up or come by tugs.

1792. They never bring eels up in their wells?—No, I never knew them do so; not lately.

1793. Were you at the meeting at the "Golden Anchor," by-the-bye?—No.

Re-examined by Mr. Morice.

1794. You say that there was nothing to complain of in the river. Do you mean in the upper part at Greenwich or lower down the river?—Before the outfall was opened.

1795. What part of the river did you mean when you said that there was nothing to complain of?—Before the outfall was opened the water was good all over. We could drink the water at Gravesend when there had been heavy rain; but now you cannot drink any at all because it would poison you.

Examined by the Commission.

1796. (*Chairman.*) I suppose that at some part up the river what you call the bad effect of this sewage ends, does it not. Does it ever reach as far as Deptford?—No, it does not get up as far as Deptford. I never knew it get as far up as that.

1797. Is the water at Deptford now better or worse than or the same as it used to be some 20 years ago?—It is not fit to drink there now,

1798. Do you know why?—I do not know the reason why. There is no fish there either.

1799. That is not owing to this sewage?—I cannot say that that is owing to the sewage. I do not know.

1800. You said that the affect of the discharge of this sewage ceases at some point up the river?—It comes up to about what we call "Bugsby's Hole," and above.

1801. In parts of the Thames mud, at all events, there used to be red worms, used there not?—There was.

1802. And if you threw a stone on the mud they all disappeared, did they not?—No, I never saw them.

1803. Are there any of those red worms now anywhere?—There are none at all.

1804. Can you tell me any spot where there used to be mud, where they were?—Yes, in Erith Rands there used to be a deal of those red worms on the mud.

1805. What has become of them; are they all gone?—They are all killed, I suppose.

1806. Do you find them lower down the river still? No, I have never seen any at all lately.

1807. I mean as low down as Grays or Gravesend?—I never saw any at all lately anywhere.

1808. They are killed all the way down?—I do not know where they are gone to. I never see any down there at any time.

1809. (*Sir B. Maxwell.*) Until 10 or 11 years ago you used to be a fisherman?—Yes.

1810. Since then you have been a waterman?—Yes.

1811. Since you have been a waterman how far up the river do you come?—I come up to Billingsgate.

1812. Do you come above bridge at all?—No.

1813. You come as far as the Custom House or Billingsgate?—Yes.

1814. Do you come as often as once a month as far as Billingsgate?—Yes; once or twice a week sometimes.

1815. How low down the river do you go?—We go sometimes as far as the Nore and Southend.

1816. That is not often, is it; you say you generally go down to about Gravesend?—Below that.

1817. You live at Greenwich?—Yes.

1818. How far below Gravesend do you generally go?—It is all according to the weather. We cannot go in our boats down there if it is blowing very heavily.

1819. You pull a wherry, do you not?—Yes, a skiff.

1820. For carrying passengers?—No, I do not carry any passengers; I work for shipping.

1821. (*Chairman.*) What is called "waiting on ships"?—Yes; piloting these small craft up and down.

1822. (*Sir B. Maxwell.*) Do you ever go down as far as Chatham or Rochester?—I do not go down there now. I have been at Queenborough whitebait fishing.

1823. How long is it since you have been as far as Rochester?—It is a long while ago since I was up as far as Rochester.

1824. Have you been there for the last 10 years?—I have not been there for the last 20 years.

1825. Then you cannot tell us very much about the state of the Medway?—I cannot.

The witness withdrew.



Mr. Thomas Parkinson called in and examined by Mr. Morice.

1826. I believe you are a Trinity pilot and waterman?—Yes. I served my time to the water and I am a pilot. I have my license in my pocket. I have been on the river pretty well all my lifetime. I was about 10 years old when I first went on the river.

1827. You have been on the water all your life?—Pretty well.

1828. Do you remember the outfalls being made in the river?—I remember it before there were any outfalls at all.

*Mr. T. Parkinson.*

15 Nov. 1882.

1829. What was the state of the river before the outfalls were made?—The water was all good and the shores clean mud; but now it is all a yellow green, all sorts of colours. Where it was sand it is all muck, and where we had 15 and 16 feet of water in Half-way Reach, we have about 9 feet now.

1830. How long ago was that?—Before we had the outfalls. I am sure I cannot say for a year or two how long it is.

1831. And now you have only 9 feet?—About 9 feet now. No ships bring up on the south shore at all now; there is not water for them.

1832. What vessels used to bring up on the south shore?—Colliers; all coasting vessels.

1833. You say that the water was very good; do you know whether vessels used to fill in water?—Yes.

1834. In what part of the river did they fill in water?—As far down as Long Reach, I have known them fill it at low water.

1835. How long ago did they give that up?—A long time now.

1836. Could you say how many years?—I could not say. I never took that notice, but they have not done it for some years past. When I was apprenticed to my father we always drank the water out of the river.

1837. You do not drink it now?—No.

1838. Why not?—Because it is rank poison.

1839. (*Chairman.*) It has been admitted very explicitly that formerly vessels did get their water from the Thames. and that now they cannot do it.

1840. (*Witness.*) All the transports, all the Botany Bay ships filled their water when they lay at Woolwich, and took it in there for the convicts. They used to have a wooden pump over the side to pump the water into the casks or tanks or whatever they had.

1841. (*Chairman.*) Did they do that in the Pool?—No; the collier ships dipped their casks in the Pool.

1842. But the sewage does not reach up to there at all?—I do not know. I never heard of any ships taking in water there at all now.

1843. They used to take it in the Pool, but they do not take it now in the Pool?—They do not.

1844. That is not in consequence of this sewage, is it?—I suppose it must be through that.

1845. Does the sewage ever get up to the Pool?—I do not see why it should not.

1846. Do you see why it should?—I cannot see why it should not. We can go further on the flood than we can on the ebb.

1847. (*Mr. Morice.*) As you have been a pilot, you have had something to do with anchoring in the river have you not?—Yes.

1848. In getting the anchor up have you ever found any deposit of mud of any kind?—You find plenty of muck on it and on the chain too. You have to get a boat forward with a bass broom to wash the muck and dirt off the chain as it comes in, or else the deck would be smothered with it.

1849. You are obliged to have somebody forward in a boat in order to get the mud and dirt off the chain?—Yes; you have a hand in a boat with a broom, and as you heave the chain in they wash it off outside.

1850. You said there was muck upon it?—You cannot call it anything else; it is all sorts of muck.

1851. Is there any smell or stink about the muck that you get up on the anchor and chain?—Yes, I warrant you it smells.

1852. You say that it stinks?—As you heave the chain in, so this muck comes up.

1853. Is it ordinary mud, or what is it?—It is muck; it is not mud, and it smells fit to choke you.

1854. And you say that you have a boat with a hand in it in order to sweep it off before it comes up?—Yes.

1855. That is to prevent its coming on to the deck?—Yes, to keep it from coming in board.

1856. Has this been getting worse in the last few years?—I think it gets worse and worse every year. We find a good deal less water all the way down about Halfway Reach and Tripcock Reach and different places. Even from Blackwall Point, as you go down along there, you find that the mud is collecting, and dirt and muck is collecting there, where we used to have good water all along. Now there is hardly any water at all right away along down to Bugsby's Hole, Woolwich Reach, and Tripcock Reach, right away down Halfway Reach.

1857. (*Chairman.*) The first places that you named are above the outlets, are they not?—Decidedly so.

1858. But you say there is still a silting up there?—There is a silting up all along on the opposite shore on the north side in Woolwich Reach. It is growing up very much lately.

1859. (*Mr. Morice.*) That is above Halfway Reach and then down past Erith?—Yes; right down Long Reach.

1860. You know Erith Bight, I suppose, pretty well?—Yes.

1861. Will you tell us if there has been any alteration in the mud, or whatever it is, in Erith Bight in the last few years?—There used to be sand at Jenningtree Point where the barges used to get the sand. Now it is all covered with mud, or I do not say mud, but it is all muck.

1862. You know the sweep right round Erith Bight down to the Causeway?—Yes, certainly. They have raised that Causeway two or three times. The old Causeway is, I dare say, two or three feet down in the mud.

1863. What sort of stuff is that?—It is all soft muck. It is all different colours.

1864. In going up and down the river, have you noticed any smell from it?—Yes, and when we heave a ship's anchor up you can smell it; and if I am on board of a screw or towing up astern of a steamboat she will stir it up at low-water time, and it will smell fit to choke you.

1865. At what time of year is it the worst?—In the summer it is the worst, in the hot weather. It smells worse then than it does in the cold weather.

1866. Have you noticed, in going up and down the river, fishermen in different parts of the river?—Yes.

1867. When did you use to meet with them?—When I was master of a steamer, about 30 years ago. I was master of a boat called the "Swiftsure" when first the propellers came in. We were riding opposite where the "Trafalgar" is built now, and the fishermen used to come inside of us and put their nets over, and catch the whitebait and send them to London.

1868. And now you do not meet with them?—Lord a' mercy, there is not a tittlebat that would live there now. I have not seen one.

Cross-examined by Mr. Bidder.

1869. You say that the river smells, as I understand you, principally in the summer?—More so in the summer than in the winter.

1870. Can you point to any place where it principally smells?—Half-way Reach for one place. Even in Limehouse Reach you can smell it, and on board the Woolwich boats at low water.

1871. Principally at Halfway Reach?—Halfway Reach, Tripcock, Woolwich, and those places.

1872. Nobody can go up and down without smelling it?—No.

1873. (*Chairman.*) Do you say that Long Reach has silted up?—Long Reach, Erith Reach, and Halfway Reach.

1874. Long Reach is between Purfleet and Greenhithe, is it not?—Yes.

1875. That you say is silted up?—There is mud; it is very bad there in Long Reach.

1876. At low water what is the mud on deposit at the sides; is it the old mud that used to be there?—No, it is more like the colour of this table, a sort of brown.

1877. How far down the river does this style of mud or deposit go?—I have seen it in the lower part of Long Reach. In fact I have seen nearly as far down as the pier at Gravesend. No longer ago than last Sunday morning I was noticing the stuff that had settled there.

1878. Do not people bathe at Gravesend?—I have not seen anyone bathe there for a long time now.

1879. I thought there used to be machines there?—There used to be machines at Northfleet, but they have done away with them and there are none now.

1880. Do you smell it down there?—Yes, you can smell it there at times. In Long Reach you can smell it very strong.

1881. (*Sir B. Maxwell.*) Do I rightly understand you to say that Halfway Reach, which was formerly 15 feet deep, is now only 9 feet deep?—There are only 9 feet of water.

1882. At what part of the Reach is that?—In what they call the collier section from Halfway house down as far as Jenningtree Point.

1883. (*Chairman.*) Do you mean that vessels of the same burden that used to come up cannot come up?—They do come up, but they cannot ride in Halfway Reach. Their section is filled up. Where the colliers used to be sectioned, there is only 9 feet now.

1884. (*Mr. Bidder.*) It is the same thing, my Lord; it is a bank off Crossness.

1885. (*Chairman.*) I think you admitted that too.

1886. (*Mr. Bidder.*) There is not the slightest doubt that a bank has accumulated in recent years on the south side of Halfway Reach, and I dare say his figures are correct. That is the bank which was the subject of the previous arbitration.

1887. (*Chairman.*) But there is more water on the north side, is there not?—Yes, there is more water there. At Dagenham Dock there is good water; they have taken the shelf away.

The witness withdrew.

1888. (*Chairman.*) I do not know whether the Commission would think that we should see samples of this stuff?

1889. (*Mr. Balfour Browne.*) The City have samples which will be produced before you at the proper time, both of the water and of the mud or "muck," as the witness calls it.

1890. (*Mr. Morice.*) I have other witnesses to call, and one of my witnesses, Mr. Charles Beadel, offered to produce some of this very mud which has been taken from Erith Causeway.

1891. (*Chairman.*) One has had a great many cases where the question has been whether there was a right of way for example. A dozen witnesses have been called, and they say, "I always thought there "was a way, and I used it and I never was stopped," and so on. It is no use calling another dozen to the same effect; you may take it that in the neighbourhood there are twenty-four people who would say so; and then without saying that that proves the right of way, you say, "It is no use calling more witnesses to prove this." Then you wait and hear what the case is on the other side. May we not deal with this case in a somewhat similar way? There are many very respectable people who come with a strong impression, for which they give thsir reasons, that the sewage has contaminated the water, and has left a deposit and that the shore is offensive, as has been described to us. Is it any use calling another dozen witnesses to say the same thing? I would suggest that to the learned counsel, although I have not consulted my colleagues. Do not suppose that my suggestion is that the case is made out. All I say is that there are a great many people who believe the same thing that these witnesses have told us.

1892. (*Mr. Morice.*) I may tell your Lordship that I have a great number of witnesses who can speak to the facts which have been deposed to already and to other points bearing upon the same matter. They are of different classes; but I am quite willing to leave the matter in your Lordship's hands.

1893. (*Chairman.*) I dare say Mr. Bidder would admit that you could call twenty more witnesses who could state the same facts, and honestly believe them, as the witnesses have.

1894. (*Mr. Morice.*) I could call a great many more than twenty.

1895. (*Chairman.*) The more you could call the more fear I have of your not accepting my suggestion.

1896. (*Mr. Morice.*) I have already tendered to me proofs to the extent of between 200 and 300 witnesses, who will state the same thing.

1897. (*Chairman.*) That shows, I think, the reasonableness of my suggestion. There is a very large number of people who entertain the same opinions, and would give the same reasons for them as the respectable witnesses whom you have called before us. I dare say Mr. Bidder would admit that.

1898. (*Mr. Bidder.*) My Lord, I go further, because as I have indicated to your Lordship to a great extent, I admit the facts. For instance, about these banks in Halfway Reach and opposite the northern outfall, I admit the fact, because I admitted it in the previous arbitration. I have thrashed it out, and I know every turn and corner of it.

1899. (*Chairman.*) And that the water is no longer used by shipping, and that fish are no longer caught where they used to be caught?

1900. (*Mr. Bidder.*) Yes. Then as regards the smell, I do not admit all that these gentlemen say, but I admit that if you go into the neighbourhood of the outfall you smell a smell. Beyond that, it is a matter the Commission can judge for themselves.

1901. (*Chairman to Mr. Morice.*) You hear what Mr. Bidder says and perhaps you will think it over, although I do not say that if you have a very prominent, capable, intelligent, and knowing witness we should not be glad to hear him.

1902. (*Mr. Bidder.*) I indicate to-day that my learned friend may be put upon his guard, that as regards any special pollution about that causeway, Erith Bight, or any particular sewage presence there, I have very good reason to believe that Erith itself is the principal cause of the pollution.

1903. (*Chairman.*) You admit the bank, but you deny that you are the cause of it?

1904. (*Mr. Bidder.*) Quite so.

1905. (*Mr. Morice.*) My learned friend Mr. Bidder has cross-examined not only to-day but on previous occasions with regard to these Dutch eel-boats, and he has also given me an indication that he contests the point with regard to the pollution of the water, because he does not admit that part. My case here is not simply that the water has been deteriorated in the ordinary sense, and that the ships' crews do not drink it, but that there is a sewage pollution which is not only in the water but which also affects persons who have business connected with the water.

1906. (*Mr. Bidder.*) I am anxious to help the Commission to shorten the proceedings in any way I can, but I should be very sorry whilst doing that to lay myself open to its being said that I misled my learned friend as to what I admit. I admit most distinctly that fish are not caught in those parts of the river where they used to be caught, and that to some extent it is considered desirable to take them out of the wells when they come up to Billingsgate, although I have reason to know that it is not universal. But my learned friend must not suppose that in admitting that I am admitting a polluted state of the river.

1907. (*Chairman.*) It is admitted that the difference has taken place since, and, as it were, upon the opening of these outfalls?

15 Nov. 1882.

1908. (*Mr. Bidder.*) I am told, and so far as I know, I think it had begun before, but no doubt to a great extent it has increased since.

1909. (*Chairman.*) That is a very proper admission, and we can draw our own conclusion from it, that there has been a considerable increase since the opening of the outfalls.

1910. (*Mr. Bidder.*) What I want my learned friend to understand very distinctly and pointedly is, that I draw a distinction between admitting the disappearance of the fish and admitting what my learned friend seems to think that necessarily indicates, viz., the pollution of the water, because I shall have a great deal to say about that.

1911. (*Mr. Browne.*) In reference to what my learned friend Mr. Bidder has said, his admission is with a view, as I understand it, of shortening the case, and of making it unnecessary for my learned friend to call certain witnesses whom he proposed to bring before you. That is a matter which affects my learned friend, but which also affects myself and my learned friends who appear for the Corporation. If my learned friend Mr. Beaumont Morice does not prove the facts that he has wished to substantiate, it will be necessary for us to call certain evidence before you. One part of the evidence that we proposed to bring was to show that it is impossible for any fish to live at all in the water between the outfalls and Waterloo Bridge and below the outfalls too. Of course I do not ask my learned friend to admit that it is due to pollution; we are prepared to prove that ourselves; but if he admits that that is a fact it will relieve us of the necessity of proving it. As for the inference we shall put evidence before you that we hope will convince you that our inference is correct.

1912. (*Chairman.*) Do I rightly understand you to say that you impeach the river from Waterloo Bridge down to Gravesend?

1913. (*Mr. Browne.*) Yes.

1914. (*Chairman.*) And you say that that state of things is attributable to these works of the Metropolitan Board?

1915. (*Mr. Browne.*) Entirely to them.

1916. (*Chairman.*) You say that some of the sewage finds its way back from the outfalls even as far as Waterloo Bridge?

1917. (*Mr. Browne.*) Yes, distinctly so, my Lord; and if I may refer to what the witness said in answer to your Lordship, he said that the water moves more up on the flood than it moves back on the ebb.

1918. (*Chairman.*) I thought it had been said that they had experimented upon it and found that it did not go above Greenwich.

1919. (*Mr. Browne.*) We have had very careful experiments made, and at the right time we will lay them before you.

1920. (*Mr. Bidder.*) The admission that I have made to my learned friend Mr. Beaumont Morice, of course, applies to my learned friend Mr. Balfour Browne's benefit too, as far as it goes; but as to admitting that fish do not live between the outfalls and Waterloo Bridge, I cannot admit that, because I happen to know that they do live.

1921. (*Mr. Browne.*) And I happen to know that they do not.

1922. (*Chairman.*) You say, Mr. Bidder, that although the fish may be poisoned by the outfalls, the water is not thereby polluted?

1923. (*Mr. Bidder.*) I do not think, my Lord, I used the word "poisoned." I do not for a moment admit that fish have been poisoned. I have good reason to know that they have not. The fact which I admit is that fish are not to be found where they used to be found, and that it is not as a rule found expedient to bring them living in the wells from below the outfall to above it.

1924. But you say that that is not owing to this discharge from the outfalls.

1925. (*Mr. Bidder.*) I will leave my learned friend to draw any inference he likes from it.

1926. (*Chairman.*) But supposing that it is, do you still say that there is not a pollution of the water?

1927. (*Mr. Bidder.*) Yes, my Lord.

Adjourned to Friday next at half-past 1 o'clock.

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# FIFTH DAY.

## Friday, 17th November 1882.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary*

Mr. WILLIAM BRILL called in, and examined by Mr. BEAUMONT MORICE.

*W. Brill.*
*M* ——
17 Nov. 1882.

1928. You, I believe, live at Woolwich?—Yes.

1929. And I believe you have been a fisherman for a considerable time?—Nearly 50 years.

1930. Can you tell us if you remember when the sewage outfalls were opened?—To the best of my knowledge about 17 or 18 years ago.

1931. What was the state of the river before they were opened?—It was in a very pure state.

1932. Where did you generally find the best fishing ground in the river?—From Greenhithe to Blackwall.

1933. (*Chairman.*) You may take this very shortly, for there has been no cross-examination upon it. (*To the witness.*) Since that time you have not found any fish there?—No; not this side of Erith since the opening of the outfall.

1934. (*Mr. Beaumont Morice.*) How far have you to go down the river in order to get fish?—To the Lower Hope—not this side; that is about 10 miles below Gravesend.

1935. Used you to be able to get any worms or bait in the river?—Yes, there used to be a worm bred in the mud. Fish used to feed ashore on the mud.

1936. What kind of worms were they?—They were a sort of red worm.

1937. (*Chairman.*) And those worms have disappeared?—Entirely.

1938. (*Mr. Beaumont Morice.*) Do you remember the state of the shore down the river on the south side; was it fairly clean?—Yes, it was clean all the way down previous to the sewage coming down, and we could go and work our net along shore, and catch a large quantity of fish.

1939. How has it since altered in character?—From the time that the outfalls have discharged into the river there has been nothing to be caught along shore this side of Long Reach.

1940. But has there been a dry hard shore like there was before?—No; all slushy muck; nothing could live on it.

1941. Is that mud, or what is it?—It is imitating a cesspool more than anything.

1942. When you say "imitating a cesspool," do you mean that it smells?—Yes, very strong.

1943. Do you know the Erith Bight from Jenningee Point?—Yes.

1944. What is the state of the tide there; does it veep round?—The tide sweeps round from Jenningee Point and down Erith Reach, and settles in Erith ight principally. The tide sets direct into Erith ight.

1945. Do you know the part that is called Church ole?—Yes, that is between Jenningtree Point and rith, opposite the church.

1946. Do you know whether there is any deposit ere along the shore?—I remember, previously to the werage, that there used to be a great deal of water Church Hole, and now it is quite shallow with a slushery" mud.

1947. How long has that been the case?—It has en getting worse and worse every year. I should ink the time I noticed it particularly is eight or ne years ago.

1948. Has there been any alteration in the last few ars more particularly?—Oh yes; it is growing very st lately, and in fact all along Erith.

1949. Have you noticed whether the sewage which ttles there is washed away at all by the action of the de?—If it does wash away it very soon appears gain.

1950. Then do I correctly understand you that it creases?—It still increases.

1951. Have you noticed any smell from that part?—Yes.

1952. Can you tell us what the smell is like?—I annot compare it to anything else than a smell from privy.

1953. Have you ever felt any bad effects from the mell?—No, I have not; it has never affected me.

1954. You go up and down the river a good deal?—Yes, I go up and down the river. I have frequently ad to put my handkerchief to my nose because of the ench.

1955. Have you ever been in the habit of drinking e water or of washing in the river?—Yes, I have runk it between Erith and Greenhithe.

1956. When was that?—A long time ago, previous the sewerage; nearly 20 years ago, I should say.

1957. Have you done it lately?—No.

1958. Do you know, from going up and down the ver, how far the sewage goes?—I should think that the farthest it does not reach lower than the lower art of Gravesend Reach.

1959. (*Sir John Coode.*) What makes you say that; ave you had any occasion to observe specially that art of the river?—Yes, we keep fish in the boat's ell, and as soon as this sewage water comes down e have to shift lower down to keep our fish alive.

1960. How do you ascertain that you have passed ut of the sewage water?—We can tell by our fish.

1961. But I thought the fish were out of the water?—No; we keep them in the well, and as soon as we nd the bad water coming down we watch the fish nd we shift our boat.

1962. Can you tell by the action of the fish then?—Yes; as soon as the fish begin to taste bad water they fly about like mad, and if we were not to shift the boat they would very soon be all dead.

1963. Then by what do you judge that the water is fit for you to put the fish into again with safety?—We can always tell by experience. When we get lower down on the flood tide it forces the water back again.

1964. Then is it the difference in the colour of the water?—Yes, there is a difference.

1965. In the appearance of the water?—In the appearance of the water.

1966. (*Mr. Beaumont Morice.*) What is the appearance of the water when you are in the sewage?—It is of a very greasy nature.

1967. Does it have any effect upon your boats or nets?—Yes.

1968. In what way?—If we were to work a net in the sewage water it would very soon get rotten.

1969. What colour is the sewage water?—It is a sort of green greasy nature to look at it.

1970. Have you ever found any lumps of sewage there, as well as the liquid sewage?—Yes, plenty.

1971. Whereabouts do you generally find them?—You will find them nearly all over the river, as the discharge comes.

1972. Have you ever found any of the sewage above Crossness?—Yes.

1973. At what part can you put the fish into the water again?—Not before you get above Greenwich or Limehouse; about there.

1974. How lately have you been fishing?—I have not been fishing now for nearly a twelvemonth. I had a misfortune.

1975. Up to last year you were fishing?—Yes. A little later than this I had a misfortune. My boat sank, and I lost my gear, and I have not been able to replace them.

1976. Up to last year you have been fishing?—Yes.

1977. Is the mud, or the muck as you call it, that you have noticed on the bank anything like the mud that used to be in the river?—Do you mean where the tide flows over?

1978. Yes, the ordinary Thames mud?—Oh dear, no; not a bit like it.

1979. Do you know anything of the River Medway?—No.

1980. Why do you tell us that the mud now is different from the mud that there used to be?—Because it used to be a hard pure mud; you could walk in it and it would only come half up to your knee, and now if you got into it it would come up to your middle; it is slushy.

1981. Is there any smell from it?—Yes.

1982. When do you find it smell worst?—It is almost always very bad.

1983. But is there any time more than another when you find it smell?—If the weather is warm you will find it very, very bad.

Cross-examined by Mr. Norman Bazalgette.

1984. I understand you to say that the fish have now all gone down below the Lower Hope?—Yes.

1985. And the Lower Hope you say is about 10 miles below Gravesend?—Nine or 10 miles.

1986. Is it not about 5½ miles; have you ever measured it?—I have not.

1987. Then you are speaking simply from your impression; you have no knowledge of the fact?—I have no knowledge of the fact.

1988. You say that all these red worms have disappeared; where have they gone to?—They are destroyed in the mud.

1989. Then they do not exist in any part of the river now?—Not this side of the Lower Hope.

1990. Do you find them when you get down to the Lower Hope?—No. I think not. I think there are not any there, because it is of a very sandy nature.

1991. Then they have disappeared from the river altogether?—Yes, where I have been fishing.

1992. You are a good deal on the river are you not?—Yes.

1993. You enjoy pretty good health, I suppose?—Yes, very good health.

1994. You have not a very large doctor's bill to pay?—Not very.

1995. You say that about 20 years ago you used to drink Thames water?—I did.

1996. Then you left off drinking Thames water some years before the outfalls opened, I suppose?—It is 20 years ago; but it is previous to the sewage coming in.

1997. You left off drinking Thames water at any rate before the outfalls were opened?—Yes.

*. W. Brill.*
Nov. 1882.

Re-examined by Mr. BEAUMONT MORICE.

1998. Can you tell us when you left off drinking Thames water?—Not exactly to a year or two.

1999. (*Sir John Coode.*) Why did you leave it off?—Because it was not fit to drink.

2000. And you cannot tell us the date?—No, I cannot tell you the date.

2001. You said it was before the outfalls. How long was it before the outfalls?—I cannot say how long it was before the outfalls.

2002. (*Mr. Beaumont Morice.*) Where used you to take it from when you drank it, as a rule?—I used to get it out of the river.

2003. But what part of the river?—In the middle mostly.

2004. But up any particular reach?—Not a particular reach. I have drunk it at Erith, and I have drunk it at Greenhithe, and higher up.

2005. With regard to the worms, you do not generally find worms in sand, do you?—No.

The witness withdrew.

*Mr. Young*

Mr. GEORGE YOUNG called in, and examined by Mr. BEAUMONT MORICE.

2006. You live at East Greenwich, and you have been engaged in fishing for a great number of years?—Yes, 40 years I have been fishing.

2007. (*Chairman.*) Down to the present time?—Up to last Sunday. I was up with a cargo of fish last Monday.

2008. (*Mr. Beaumont Morice.*) Do you remember the time when the outfalls were opened at Crossness and Barking?—Within a few months, I dare say.

2009. What was the state of the river before that time?—We used to catch shrimps, whitebait, flounders, and eels up at Greenwich.

2010. Down to what part of the river?—Down as ar as Erith. Erith Rands used to be our principal place for fishing.

2011. How long were you able to keep fishing in Erith Rands?—I should not think it lasted more than about two years after the sewage came into the river. It kept getting worse and worse.

2012. What did you have to do then?—It kept driving us away. We went to Greenhithe, and from Greenhithe to Gravesend, and from Gravesend to Lower Hope.

2013. And you were not able to get the fish that you had got before?—No.

2014. Then you say you were driven further down?—Yes.

2015. Where do you have to go to now for fish?—To the river Medway.

2016. Do you know the Medway at all?—Yes.

2017. What is the nearest point up towards London where you can catch a fish of any kind?—I do not know of anywhere, without it is the Lower Hope; that is about seven or eight miles below Gravesend.

2018. That is the nearest point to London?—Yes, that is the last I have caught there. The last time I was fishing there we caught a few, and they were very scarce then, and then they would not live on the low water.

2019. Then you have to go between the Lower Hope and the Medway?—Yes.

2020. You know the river very well; what sort of shore is there down by Jenningtree Point, along Erith way?—The banks are very well, but the bottom is nothing else but all filth. I lost an anchor there once; I was caught in a gale of wind, and I tried to sweep after it with a small line, and when I hauled my line in it was, I should think, three inches thick with muck and paper, and all manner of filth.

2021. Do you know whether there is any mud, or anything like mud, on the south shore down from Jenningtree Point?—Not pure mud; it is all filth.

2022. Why do you say it is filth?—Because I can prove it by a staff.

2023. Is there any smell to it?—Dreadful.

2024. What is the smell like?—Closet stuff more than anything else. If you put your hands overboard in it, you have a hard matter to get your hands clean again.

2025. From going up and down the river, can you tell us how far the sewage in the river goes down, on the ebb tide?—The fish would not live at Gravesend on the low water. I think it goes about there.

2026. That is the way you are able to tell?—Yes.

2027. How do you find that fish will not live there?—No longer ago than last Sunday evening I was sailing up with all my fish in the water, and when I got into Long Reach I had to sweep my fish out, and spread them all about the vessel till I got to the Upper Pool in London, and then I put them into the water, and they lived then.

2028. (*Sir John Coode.*) When you say that you had to pull them all out, why did you have to do so?—Because they were just the same as if they were drunken men, with the filth of the water.

2029. (*Colonel Ewart.*) But where did this begin?—In Long Reach; it was on the high water time.

2030. (*Mr. Abernethy.*) You came up on the flood?—We came up on the flood, and it was about an hour-and-a-half ebb.

2031. (*Sir John Coode.*) Might not that have happened if the water had been fresh water and free from sewage?—No.

2032. The fish that you had caught were salt water fish, I suppose?—That does not matter; they will live in good fresh water, because I put them in fresh water when I was in the Upper Pool.

2033. Did they not seem like drunken men then?—No; the water is pure and good at London.

2034. (*Mr. Beaumont Morice.*) Does the water have any effect upon your boat or nets?—Where our nets wanted tanning once a month we have to tan them every week now, or else they would rot away; and then with regard to the boats' bottoms, if you dressed a boat's bottom at one time you could let it go for two or three weeks; but now, every time you come up she wants her bottom scrubbed.

2035. Was there at any time any hard bottom or shore down the river near Jenningtree Point, or Erith?—At one time of day there was. There was good food for fish then. There used to be a nice hard sandy bottom, with a little red worm, which the fish used to feed on.

2036. Are there any of those worms left now?—No, nothing at all would live there.

2037. Do you know whether there is any settlement of filth in the Bight?—I have proved it by losing an anchor, and I tried to sweep the anchor with a sweep line and it went right under, and I tried with a staff, and I could shove the staff down 6 or 8 feet all in filth.

2038. Do you know the Causeway at Erith?—Yes, perfectly well.

2039. Has there been any alteration in that in the last few years.

2040. (*Chairman.*) It has been lengthened, has it not?—I think it has been lengthened.

2041. (*Mr. Beaumont Morice.*) Do you know whether there is any deposit of this stuff near that causeway?—It runs all down there.

2042. But has there been any increase in the last few years?—Wonderful.

2043. Used you ever to use that causeway to moor your boats to?—Yes.

2044. Can you do so now?—No, we never moor there now.

2045. Why?—It does not trouble us, because we do not fish there.

2046. Could you do it if you wanted to?—I do not believe that an anchor would hold if there was any wind at all, for it is all of a "slather."

Examined by Mr. Lumley Smith.

2047. Below the place where the sewage affects the water, are the worms found still where they used to be found?—No, there are no worms found there at all.

2048. That is where the sewage comes?—All the way down the north side and the south side; each side is poisoned.

2049. (*Chairman.*) Do you find any at the Lower Hope?—No, the fish will not live there at low water if there come two or three calm days; it is only a breeze of wind that keeps the fish there, if they are there.

Cross-examined by Mr. Norman Bazalgette.

2050. I understood you to say, as to the wind, in Half-way Reach, that the banks were very well, but that the bottom was all filth?—The banks were very well—the saltings.

2051. I presume you will agree with me that the banks are the parts which are exposed to the air?—The banks are where you walk along, and the saltings are different altogether; the saltings are outside the banks.

2052. The banks are very well?—That has nothing to do with it. It is only to keep the water out of the marsh; but the saltings are a different thing.

2053. Are you much upon the river?—Yes, winter and summer.

2054. Do you enjoy pretty good health?—Not when I am about Erith. I cannot a-bear it. I dare say you have experienced the same feeling as I have when you have been going down in a steamboat.

2055. Do you mean that you have been actually taken ill, and had to consult your medical adviser?—Not exactly that. If I am aboard of a steamer I am very glad to go and get three penn'orth of brandy for to cheer myself up a bit. I am forced to put my handkerchief up to my nose to keep the smells away and not only me, but the other passengers as well.

2056. How often do you go past there in a day?—Not often in a day.

2057. Then you do not often have to apply this remedy?—No, it would not do.

2058. You told us that the fish would not live at Gravesend, and it is from the disappearance of the fish that you judge that the sewage comes there, is it?—It is. Of course the sewage water reaches there.

2059. Then you may catch fish at one point, and half a mile higher up you may not catch them at all?—That may be so at times.

2060. Can you tell me by eye, or nose, the difference between the point where you can catch the fish and the place where the fish disappear: is the distance half a mile?—Half a mile is only a short distance. I would not say for half a mile. It might be a mile and a half.

2061. Therefore, the absence of the fish is the only indication that you have of the presence of the sewage?—That is all.

2062. You told us just now that you had to tan your nets once a month?—We used to, but now we have to do it every eight or nine days.

2063. Do you still fish in the Thames?—At times at the Lower Hope. That is the highest we can fish.

2064. And you have to tan your nets once a week at the Lower Hope?—Yes.

2065. And you attribute that to the sewage?—Certainly, nothing else rots the twine but that. That is what all our fishermen reckon it is.

2066. But you find the fish at the Lower Hope?—At high water. But at low water there are none. You might find fish at high water at Gravesend, but there are none at low water.

2067. Am I to understand as the result of your evidence that there are no red worms to be found in the Thames now?—For a certain distance.

2068. Where can you find them now?—I do not know. I cannot answer that question.

2069. Can you find any above the outfalls?—I do not think you can without it was well up the river. You might get some there.

2070. I ask the question because I heard you talk about a nice sandy bottom with red worms in it?—It used to be.

2071. You are speaking of times long gone by?—Not of the present time.

2072. You know of no red worms to be caught in the Thames just above or below the outfalls?—No.

Re-examined by Mr. Beaumont Morice.

2073. With regard to this fishing, I understand you to say that you have been driven down the river?—Yes, every year.

2074. As a matter of fact, do you attempt to fish above the Lower Hope?—The last time I shot my lines was off Grays, and I baited them with whitebait and shrimps, on purpose to see whether the fish would take either, and I never saw the sign of a fish at all. The baits came in on the hooks just the same way as I shot them off.

2075. That is at the top of Northfleet Hope?—Yes, right off Grays; that is where I shot my lines. That was just before that heavy gale of wind.

2076. Then, as a matter of fact, you do not get any fishing up in this part of the river at all?—No, none at all.

2077. With regard to what you were asked about the banks, that is above what you have been talking about as to where the mud is?—The bank is.

2078. It has nothing to do with the slushy part?—No, there are the saltings astride the bank.

2079. Is or is not this deposit of slush a distinct thing from the bank and from the saltings as well, and what is the difference between what you consider deposit and what you consider mud?—You must understand that at high water and at low water the tide is at a standstill, and that has time to settle a bit till the tide begins to run again; and then it moves it a bit, so that the mud cannot be such a great way up. The mud does not reach the bank. The bank has nothing at all to do with the bottom of the river.

2080. So that the bank has nothing to do with it?—No.

2081. I take it from you, that whenever you come past Erith, and the reaches above Erith, you smell this smell that you have told us of?—Yes, and not only that, but directly the fish touch the bad water we are forced to sweep them out and spread them out about the vessel.

2082. And of that you had experience quite recently?—Only on Sunday.

2083. (*Sir John Coode.*) If an inch rope came in three inches thick, owing to the quantity of mud that accumulated round it, how was it that the bait came in as clean as when you first put it overboard?—I said the bait came in whole; it had not been touched by the fish.

2084. But if the inch rope became coated three inches thick with mud, how is it that the bait came in so clean and whole?—It did not come in so clean.

2085. You said just as clean, you meant just as whole?—The hooks are bound to catch this stuff, paper, and all sorts of things.

2086. (*Chairman.*) The bait was all foul as well as the rope?—Yes, all much alike. I meant whole; not touched by the fish.

The witness withdrew.

*Mr. T. H. Sibley.*

17 Nov. 1882.

Mr. THOMAS HARRY SIBLEY is called in; and examined by Mr. BEAUMONT MORICE.

2087. You live, I believe, at Erith, and you are foreman and lighterman for Messieurs Pigou and Wilkes?—Yes, through Mr. Brydges.

2088. Do you know the river?—Yes.

2089. What are your duties as regards the river?—At present to see the craft loaded and unloaded in the Magazine Creek at Halfway Reach, just below the outfall.

2090. What is the state of the river, so far as you have seen, at that part?—Very filthy.

2091. What do you mean by "very filthy"?—In a filthy state, owing to the refuse that comes from the outfalls.

2092. Is there any smell, or anything offensive about it?—Yes, very much so in hot weather.

2093. What is the smell like, in ordinary language?—I can compare it to nothing else than a parcel of dead bodies floating about.

2094. It smells like that?—Something similar to that.

2095. A rotten sort of smell?—It is so.

2096. Is there much mud about in that creek?—I do not know so much about mud; there is a lot of slush that we have to encounter.

2097. What is the slush like?—I can compare it to nothing but sewage.

2098. What is the colour of it?—It is more like night-soil than anything else.

2099. Does it smell offensively, then?—Yes, very.

2100. Is there much of it there?—A very great deal.

2101. Does it increase at all?—Yes, wonderfully.

2102. Do you do anything when you find that it is increasing so much?—If it was not for the sluice that we have to carry it away in our Magazine Creek, in less than six months, I suppose, we should be blocked out there altogether, and we should not be able to get in.

2103. You have a sluice, you say?—Yes.

2104. And you open this sluice and that clears it?—Yes; and we keep the water in; and when the tide is going down we open the sluice again to make our roadway into the creek navigable, so that we can get in and out.

2105. That is to say the creek fills up with this sewage stuff?—Just so.

2106. And you have to cleanse it with a sluice?—Yes, and we do it frequently.

2107. How often do you do it?—About every fortnight.

2108. How long have you been there at work?—I have been working in and out there, 16 years.

2109. Were you there before or after the outfall was made?—I went there just after the outfall was opened.

2110. A short time afterwards, I suppose?—Yes.

2111. When you went there did you have to do this sort of thing that you have been describing?—No; I do not know that we used to do it more than once in three months.

2112. From what period have you had to do it as often as once a fortnight?—It is owing to the settlings that come from the sewage.

2113. For how many years have you had to do it so much oftener?—I should think for these last 10 years.

2114. And at the time you came, I understand, the outfalls were just opened?—They were just open.

2115. Is there any stench about this stuff?—Yes, a great lot.

2116. Have you ever felt any ill effects from the stench?—So much so that sometimes in hot weather we have had to knock off work.

2117. You say "you"; there are several of you, are there?—Yes, there are five or six as a rule. We have had to knock off work, and we have felt very queer at the time.

2118. How long have you known the river altogether?—Something like 24 years.

2119. Was there anything like this to your knowledge before the outfalls were opened?—Never.

2120. What was the state of the river then at that place?—There was nothing, only mud then, which is of course more sand than mud, according to how the tides run.

2121. Do you know anything of the shore between Jenningtree Point down Erith way?—Yes.

2122. Do you know whether there is any deposit or collection of mud or anything else there?—A very great deal in Church Hole.

2123. Church Hole is halfway between Jenningtree Point and Erith, is it not?—Just so.

2124. What is the sort of stuff that collected there?—Nothing but sewage, from what I can see of it. I can remember the time when large ships used to bring up in Church Hole; and now there is no water there at all scarcely.

2125. Is there any tide round there in Church Hole?—There is an eddy-tide, sometimes, on the ebb-tide.

2126. Has there been any settlement of this stuff there?—A great deal.

2127. Has there been much for the last few years more particularly?—Yes.

2128. (*Chairman.*) That is not disputed. It was quite plainly admitted, I understood, that there was a great settlement in Erith Bight. The explanation that will be offered by Mr. Bazalgette will be different from yours; but the fact that there is a great silting there, is really beyond question, I think.

2129. (*Mr. Beaumont Morice.*) I think my learned friend's admission had reference more to the bank in Halfway Reach.

2130. (*Chairman.*) That is also admitted.

2131. (*Mr. Beaumont Morice to the witness.*)—Has this state of things, about which you have been speaking, remained about the same for the last few years, or has it increased?—I think it has increased very greatly.

2132. Have you ever noticed anything of the sewage in the water?—Something of all sorts.

2133. Has there ever been anything on the water that you have noticed like sewage?—Yes, plenty of times.

2134. Have you ever noticed anything being taken out of the river?—Yes, I have.

2135. What have you seen?—Grease in particular. I have seen people come inside of our Magazine Creek and collect something like half a hundredweight of grease at a time; and I firmly believe that several parties get their living by it.

2136. How do they collect it?—With a small net with a handle to it, and a boat, and they skim it up.

2137. Is there any particular time of the tide at which they do that?—Generally speaking when it is high-water time with the wind on the land.

2138. At what time does the sewage begin to come out?—Something about high-water time.

Cross-examined by Mr. NORMAN BAZALGETTE.

2139. How long have you been in your present situation?—Sixteen years.

2140. When you first came there which of these places was within 300 yards of Magazine Creek, Johnson's Fish Manure Works, Bevington's Manure Works, Collins's Manure Works, and the Belvedere Guano Company; they are all within 300 yards at the present time are they not?—I do not think so.

2141. Take the nearest, Johnson's Fish Manure Works are within 300 yards, are they not?—Yes, and over. We are the nearest to the outfall.

2142. Are you 300 yards or not from Johnson's Fish Manure Works?—I should think we were.

2143. Then immediately adjoining Johnson's Manure Works you get Bevington's Manure Works, do you not?—Yes.

2144. Then immediately adjoining Bevington's Manure Works you get Collins's Manure Works; is that right?—Yes.

2145. Then immediately opposite Magazine Creek you get a candle factory and Crossfield's Manure Works, do you not?—Yes, on the other side of the water.

2146. Which of those manure works were in operation when you first of all came to Mr. Brydges?—The Belvedere Works.

2147. They were the only ones?—They were the only ones so far as I know.

2148. The Belvedere Works have gone, have they not?—No; they call it the Belvedere Wharf now.

2149. Are the works still in operation?—Yes.

2150. Then I have a fourth one to add.

2151. (*Sir John Coode*). This Magazine Creek is about half way down Half-way Reach, is it not?—Yes.

2152. (*Mr. Norman Bazalgette.*) It is between the southern outfall and Jenningtree Point?—Yes.

2153. With regard to the processes that go on at these different places, can you tell me whether at Johnson's Manure Works, Johnson takes all the blood down from the Cattle Market in London and makes that into manure?—I am not aware of that at all.

2154. Have you ever seen the horns of cattle going into Bevington's Manure Works?—Yes.

2155. Do you not think that these processes might account for the smell of dead bodies that you have mentioned?—How can that be if there is no outfall into the river.

2156. You think it is necessary that they should go into the river before they can smell?—Decidedly; before they could upset the water.

2157. You say that this smell has been continually increasing?—Just so.

2158. You have told me that when you first came to this place, only the Belvedere Guano Company's works were open. Which came next?—I do not know.

2159. Were Johnson's the last? They have been established within the last year, have they not?—I do not know. I do not trouble myself about other people's affairs.

2160. They did not all come in a lump, did they?—No.

2161. They have been established there gradually?—I believe that they have come one after the other.

2162. And the smell you have told us has gone on increasing from time to time?—Yes.

2163. Is this smell to be smelt all the year round?—The particular smell from the land we can smell all the year round; but what I am speaking about is the sewage.

2164. There is a smell from the land, then?—There is a smell from the manure factories which we have to put up with all the year round.

2165. When the wind is blowing in that direction, cannot you get the smell from Crossfield's Manure Works and the candle factory, and from the other side of the river?—Yes.

2166. And that smell goes on all the year round?—Yes.

2167. But does the smell of the outfalls go on all the year round?—We do not smell them so much in the winter time.

2168. Do you smell them at all in the winter time?—Yes.

2169. If you went down the river could you smell them now?—Yes.

2170. And would they be offensive?—Yes.

2171. Most offensive where your works are?—Yes.

Re-examined by Mr. Beaumont Morice.

2172. In fact you have that smell all the year round?—Yes.

2173. And it is merely a question of how the wind is whether you get it?—Of course we get it most when the wind is on the land; anything from the north-west we are bound to get it.

2174. Are you perfectly clear that that is a distinct thing from this sewage smell?—Yes.

2175. You have no doubt about that?—I have no doubt at all.

2176. You say that there was only about one of those factories when you came there?—Only one.

2177. You were asked about Johnson's; do you know that it was established under the control of the Erith Local Board?—I do not know what it is established under.

2178. But it has been only recently established?—I believe not.

2179. As to this smell of dead bodies, you say that it could not have come from these land factories?—No, it is a different smell altogether; the sewage has a different smell altogether from the smell of those factories.

2180. You say that this sewage smell comes from the water and not from the land?—Yes, from the water and not from the land.

2181. And you live alongside of the water?—Yes, close to it.

Examined by the Commissioners.

2182. (*Colonel Ewart.*) About these works that you have been speaking of, have you ever noticed any discharge of refuse or effluent water from those works?—No, none whatever.

2183. Are there any gasworks about there?—No; only at Erith.

2184. Have you ever noticed any discharge from them?—No, nothing.

2185. (*Chairman.*) You do not go up and down the river, do you?—Yes, I do. I sail up and down the river, and I frequently walk up and down the bank.

2186. I understood you to say that your business was to see to the loading and unloading of barges?—Just so; but I go on board the craft that go up and down, and I likewise walk up and down.

2187. (*Sir John Coode.*) You knew this part of the river, I think you said, for about eight years before the sewage outfalls were opened, and the outfalls have been opened 16 years; that makes 24 years altogether?—Yes, I knew the river, but I was not in these works at that time.

2188. Did you know this part of the river well?—No; I was more down below at that time.

2189. Then you cannot tell us, of your own knowledge, what was the condition of those banks before the outfalls were opened?—No.

2190. You have spoken of the accumulation in Church Hole. We have been told that that has been brought about in a great measure by the operations of the Thames Conservancy in dredging at or near Coldharbour Point; have you any knowledge which will enable you to tell us whether this deposit in Church Hole is due to the change in the set of the tide, because we are told, on the one side, that it is, and on the other that it is not. Have you noticed any difference in the set of the tide since the dredging operations of the Thames Conservancy near Coldharbour Point?—No, I have not.

2191. You think the tides set the same as they did before?—As far as I am concerned, I believe they do.

The witness withdrew.

Mr. William Henry Joseph McKee called in; and examined by Mr. Beaumont Morice.

*Mr. W. H. J. McKee.*

17 Nov. 1882.

2192. I believe you live at Erith?—Yes.

2193. And you are foreman and lighterman to Messrs. Berry and Edwards?—Yes.

2194. Do you know the River Thames pretty well?—Yes, I have been on the river about 18 years.

2195. What are your duties on the river?—I am a gunpowder lighterman.

2196. How long have you been in your present employment?—Ten years next March.

2197. In what part of the river are you generally stationed?—Our magazine is at Jenningtree Point in Halfway Reach.

2198. Do you remember the river before the outfalls were opened?—No, not much.

2199. How long was it after the outfalls were opened that you went to Jenningtree Point?—About seven or eight years I suppose.

2200. Can you tell us what was the state of the river or the creek then?—It was pretty well like it is now, I should think.

2201. (*Sir John Coode.*) If I understand aright, you are not employed at the same magazine as the last witness?—No.

2202. Your magazine is at the Point and not in a creek?—At the Point, at Jenningtree Point, Messrs. Curtis and Harvey's magazine.

2203. (*Mr. Beaumont Morice.*) Can you tell us what is the state of the river?—At high water it is all dark fluid, and the stream comes away down from the sewers.

2204. How can you tell that it is a stream coming down from the sewers?—You can see the floating masses of excrement and that sort of thing.

2205. Do you see these floating masses constantly?—Yes, every day.

2206. At what time of the tide?—It commences just at high-water time.

2207. (*Sir John Coode.*) How can you account for ts coming down from the outfalls at high-water time when you are a mile, or a mile and a half, below the lowest outfall?—It comes away just after high water; there is an eddy tide where the magazine is, right along the shore.

2208. What you mean to say is that there is an eddy on the flood which brings this down from the outfalls before the time of high water?—Yes, there is an eddy inshore, the tide runs down inshore about two hours.

2209. (*Mr. Beaumont Morice.*) Then you find it every day, you say, coming down that way?—Yes.

2210. You have to do with a good many barges, have you not?—Yes; we have eight barges.

2211. Does it have any effect upon those barges?—They have been complaining many times in the summer time, about the stench and smell.

2212. (*Chairman.*) But the barges would not suffer from that. Mr. Morice asked you whether the barges were affected in any way?—Their sides get covered with slime.

2213. (*Mr. Beaumont Morice.*) And besides that, the bargees complain of the stench?—Yes.

2214. Do you notice any alteration in the colour of the water when the sewage comes down?—It is brown and thick.

2215. When you are there, is there any stench from it perceptible to you?—In the summer time there is.

2216. What sort of stink is it?—I can hardly say; it is very offensive.

2217. What should you call it?—Sickening, I should say.

2218. Do you ever find anything in the stream coming down with the sewage beyond the mere look of the water in a liquid state; are there any lumps?—You see a lot of lumps floating about.

2219. Does that occur often?—Yes, very often.

2220. And you say you generally find them in hot weather?—Yes.

2221. Are you near any of these factories on the shore, the glue factory, and so on?—About a quarter of a mile from the nearest I suppose.

2222. Do you find any smell from them?—Yes, at times.

2223. Are you in the habit of getting ballast from the river?—No.

2224. Do you know whether it is done?—Yes, in Long Reach now.

2225. Can you say whether or not the smell from these factories is anything like what you have been telling us about?—No; it is a different smell altogether.

Cross-examined by Mr. Norman Bazalgette.

2226. The smell from the factories is entirely distinct from that from the river?—Yes.

2227. What is the difference between them?—A great difference. The other is more manure.

2228. Which is the most manure?—The factories.

2229. They smell more of manure than the sewage does?—I think so.

2230. I think that at Jenningtree Point you are particularly favoured as regards these nuisance factories?—Yes, there are several just above there.

2231. Within a radius of 1,200 yards of Jenningtree Point, do you not get Johnson's Manure Works, Bedington's Manure Works, Collins' Glue and Manure Works, the Belvedere Grand Company's Works, Price's Oil Works, the Calendar Bitumen Works, on the one side, and on the other side Crossfield's Manure Works, the Candle Factory, the Rock Portland Cement Company, Barnes' Chemical Works, and another, the Gas Purification and Chemical Works, Wilson's Chemical Works, Miller and Johnson's Chemical Works, and the Fish Manure Works, making in all fifteen?—Yes.

2232. Will you look at the map and tell us whether, according to your view, that is a correct plan.

2233. (*Chairman.*) This is not the kind of witness to prove a map.

2234. (*Mr. Norman Bazalgette to the witness.*) You know all those places that I have mentioned?—Yes.

2235. Can you, in any wind that blows, escape some of those factories. Are you not completely surrounded by them?—Yes.

2236. You are bound, no matter what wind is blowing, to get the smell of some of them, are you not?—Yes.

2237. Does this smell, that you say proceeds from the outfalls, go on all the year round?—Yes, we do not smell it so much in the winter.

2238. (*Chairman.*) You said that you smelt it in the hot weather, as I understood?—Yes.

2239. (*Mr. Norman Bazalgette.*) But it does go on all the year round?—The sewage keeps flowing.

2240. But is the smell perceptible all the year round?—No, not so much.

2241. Have you been down at your works to-day?—No.

2242. When were you there last?—Yesterday.

2243. Did it smell then?—Not a great deal.

2244. (*Chairman.*) Did you perceive the smell at all?—No, I do not know that I did.

2245. (*Mr. Norman Bazalgette.*) Did you smell any of the factories yesterday?—Perhaps they were not at work. The wind was north-east.

Re-examined by Mr. Beaumont Morice.

2246. In the first place it depends upon the direction of the wind what you smell?—Yes, from the factories.

2247. And secondly, are those factories constantly working?—No, I do not know that they are.

2248. You know that sometimes they knock off for a few days?—Yes.

2249. (*Mr. Norman Bazalgette.*) He has just told me that no matter what wind blows, he must get the smell of some.

2250. (*Chairman to the witness.*) You say you have perceived the smell from the river only in hot weather; last summer did you perceive it at all?—Yes.

2251. How many days last summer do you suppose you perceived that smell; had we much hot weather last summer?—Not a great deal.

2252. Did you smell it ten times in the summer?—Yes, more than that.

2253. Twenty times?—I should think more than that.

2254. Fifty times?—Yes, I would not say but what I did.

2255. Sixty times; that would be two months?—I do not know about the times. It is very offensive in hot weather.

*Mr. W. H. J. McKee.*

17 Nov. 1882.

2256. (*Mr. Norman Bazalgette, through the Commission.*) What kind of health do you, and the men at your place of business, enjoy?—It does not affect me a great deal.

2257. It does not affect your appetite?—No, I do not think so.

2258. Have the men about you been in good health also?—Pretty fair; they have been spitting and complaining about.

2259. They have not left off their work?—No, they have not left off their work.

2260. (*Sir John Coode.*) You say that it does not affect you a great deal; does it affect your health at all?—At the time when it is floating by and when the smell is great.

2261. It is not agreeable, but the question was, does it affect your health?—I do not know that it does.

The witness withdrew.

Mr. John Godfrey Lee called in; and examined Mr. Beaumont Morice.

*Mr. J. G. Lee.*

2262. I believe you are the Corinthian Yacht Club waterman at Erith?—Yes.

2263. How long have you been there?—About a year and seven months now.

2264. How long have you been on the water about that part?—About the Thames, about seven years.

2265. First of all, where is the Corinthian Yacht Club at Erith?—At Church Hole, Erith.

2266. That is just in the bight by the church?—That is it.

2267. What is the state of the river at that part?—Very bad in the last quarter-ebb.

2268. Is there much of a tide in there?—There is an eddy-tide runs up for about an hour half ebb, and then it runs down again for another hour, and all the rest runs up. The sewage runs down, runs round by Erith Pier, and then runs up again, so that we catch it all at our place. It comes back on the last quarter ebb-tide. There is a little flood alongshore on the last quarter ebb, and during the time that the tide is running off it runs up in shore.

2269. What sort of stuff is collected there in this way?—Stuff from the human frame; that is as plain as I can tell you.

2270. That will do. Is there any stench from it?—Yes, plenty on a warm morning. If you walk down there before breakfast and take a few whiffs at it, you don't want much breakfast.

2271. What does it stink like?—Just like what it is.

2272. Is there much of this stuff?—Yes, in calm weather there is plenty of it. There is not so much in breezes, but when it is calm, still weather, it is there by bushels.

2273. Has the direction of the wind anything to do with it?—No, that does not affect it much.

2274. You are close on to the bight?—Right alongside of the wall.

2275. Has there been much more of this recently since you have been there?

2276. (*Chairman.*) One year and seven months he has been there.

2277. (*Witness.*) I have been on the Thames seven years; not at Erith.

2278. (*Mr. Beaumont Morice.*) During the seven years that you have been upon the river, has this sewage increased at all?—I do not see a great deal of difference between now and a year and seven months ago; but it is a lot worse than it was seven years ago.

2279. (*Sir John Coode.*) Has your health suffered from it at all?—Sometimes. You may think I do not look very unhealthy now, and no more I am; but I very often have the headache and am sick from it in the summer, but at this time of the year it does not affect me at all. To my sorrow I have wished not to be there sometimes.

2280. (*Mr. Beaumont Morice.*) Have your family suffered?—Yes; I have a little girl who is never well there. She has been away all the summer, and she has been back about six weeks, and it does not agree with my wife. I have a little boy, and it does not affect him much; I do not think anything would hurt him at all, because I think he is made of iron. My little girl has been away twice since I have been there.

2281. There is a causeway, is there not, about this creek?—Yes, it runs into the river about 350 feet down from the wall.

2282. (*Sir John Coode.*) Is that a private slipway belonging to the club?—That is a private slipway belonging to the club.

2283. It is not the same we have been hearing about.

2284. (*Mr. Beaumont Morice.*) No, this is further up the river than Church Hole. (*To the witness.*) Can you tell us what is the state of that causeway when the tide leaves it?—Yes, I can. In the hot weather, if it is not scrubbed every day it is not fit to walk up and down.

2285. Why?—Because it is all slime and dung, I was going to say (and I might as well have said so) every low-water time.

2286. It is not ordinary mud?—No; you only want to smell it to test it.

2287. Do you find this slimy stuff at any particular part of the year, or generally all the year round?—All the year round as a rule; but it does not affect us so much except in hot weather. In hot weather the smell is the worst. The slime is always there, winter and summer.

2288. That is a mere question of the tide leaving it there?—That is it.

2289. Do the stench and smell get into your throat at all?—Yes, in warm weather; it would choke you.

2290. Does this sewage affect any of the boats that lie about there at all?—Yes, if I cleaned a boat's bottom to-day, and put her off this tide at 4 o'clock, to-morrow morning I should find sewage all over her, and I must not scrub it, or else I shall have it all over alike.

2291. You have to keep the boats constantly scrubbed?—You want to clean and redress the bottoms four or five times every summer to keep them in proper order.

2292. Is any of this sewage stuff that remains there ever washed away at all?—Do you mean, what settles on the mud? If it blows a strong wind from the north-east, sometimes the sewage decreases four or five inches; and if it is still weather, it will create four or five inches in a week.

2293. But in spite of the occasional gales, the whole mass is still increasing?—As I say, it increases in fine weather and decreases in gales of wind, and when there is a gale of wind at high-water time, it is just as bad up at the top as it is at low water on a fine day. It stirs it all up.

2294. You know the river, of course, very well from the clubhouse down to Erith along the bank?—I do not know much about the bank.

2295. Not the bank itself, but the mud?—It is all alike all the way along. It is all a bight there. It has a sort of slaty surface, and underneath it is as

*Mr. J. G. Lee.*

17 Nov. 1882.

black as jet; and if you get it on to your boots or clothes it is hard to get it off. It is more like grease than anything else, and "slicker."

2296. You know the old causeway at Erith?—Yes.

2297. Is there much of this stuff there?—That I cannot answer for. I am not much down there. I am stationed at this one place, and I am not supposed to leave except on duty, so I cannot answer for that.

Cross-examined by Mr. Norman Bazalgette.

2298. Did I correctly understand you to say, in answer to the Chairman, that you had bad health at Erith?—Not bad health exactly. I have been sick several times.

2299. What did you say your family consisted of?—I have two boys and a girl, and a wife.

2300. Do not your children continually play over Erith Causeway; is not that their favourite playground?—No, not at all times.

2301. They are continually there, are they not?—Now and then.

2302. Are they as healthy as most children?—One of them is, and the other is not. That gentleman there (*pointing to a gentleman behind Mr. Beaumont Morice*) knows the little boy.

2303. Did you not tell that gentleman that the little boy never had a day's illness?—He never did.

2304. And he plays about on the Erith Causeway?—Sometimes he strolls there. You cannot always have your hand upon them.

2305. He is a fine little fellow, is he not?—He is as fine a little fellow as you will see in a day's march; like his father.

2306. There is a club-house there, is there not?—Yes.

2307. How many members are there belonging to the club-house?—That is more than I can tell you. There are 470 down on the books.

2308. Do members frequently come down to the club-house, and spend Sunday there?—Not in the club-house; on board the yacht. They come down for an hour in the morning, perhaps, for Sunday recreation.

2309. They come down for a Sunday lounge?—Yes.

2310. How many yachts belong to the club?—I cannot tell you without the books, and I have not brought them with me.

2311. Is the number increasing very rapidly?—Until this summer it has.

2312. Now with regard to the Causeway, you know the Corinthian Causeway, and you also know the old causeway at Erith?—I do not know much about the old causeway. I would not answer for that.

2313. Is there any accumulation of mud at your club causeway which corresponds at all in extent to that at the old causeway?—I do not know anything about the old causeway. I do not suppose I was ever on it more than once in my life. I can stand and see it, though I was never there.

2314. Have you seen the mud there?—I have never seen the mud there, but I have slipped into it on a dark night.

2315. Do you have much accumulation in the immediate neighbourhood of your causeway?—Not much, but it is "slickery" stuff.

2316. Your causeway is built on piles, and the other one is solid, is it not?—That is it. Ours is built on piles with the planks an inch apart.

2317. So that the water can flow under it and through it?—That is so.

Re-examined by Mr. Beaumont Morice.

2318. This Corinthian Club causeway is a comparitively new causeway built by the club, is it not?—It is a comparatively new causeway built by the club; it is private property.

2319. Do you know how many years ago it was built?—It would not be more than three years ago.

2320. With regard to the increase in the number of members, do you know, as a matter of fact, that that is the principal yachting station at Erith in place of the one down at the old peir?—Yes, because the other was broken up, so that they could not make a yachting station there.

2321. Therefore, the yachts come and lie off the Corinthian Club-house in Church Hole?—Yes.

2322. (*Chairman.*) You do not know that they ever lay down below; you have only been there a year and seven months?—They had been lying down at the old club-house before. I have had seven years in the river in yachts.

2323. At Erith?—Partly at Erith, and partly at Grays, and at Gravesend, and all the way down the river.

2324. (*Mr. Beaumont Morice.*) And off the old pier, some years ago, you know that used to be the principal station for yachts?—Yes.

2325. And now they come up to Church Hole?—They do that on account of the dirty, filthy coal at the old pier.

2356. (*Mr. Norman Bazalgette, through the Commission.*) How long has the present Corinthian Club been established in its present quarters?—I think three years last June. I remember its being built very well.

The witness withdrew.

Mr. William Hoskins called in; and examined by Mr. Beaumont Morice.

*Mr. W. Hoskins.*

2327. I think you live at Erith?—Yes.

2328. And you are a lighterman?—Yes.

2329. How long have you known the river?—I am nearly fifty years old and I have been at it all my life time. I have known the river these 40 years.

2330. Do you remember the outfalls being made at Crossness and Barking?—Yes.

2331. What was the state of the river before that time?—Before that time I have seen fishing boats at Greenwich and Erith catching shrimps and the water was clear and fresh.

2332. At Greenwich?—Yes.

2333. Whereabouts down the river did they fish?—From there to Blackwall.

2334. But down the river?—To Erith—Church Hole.

2335. Was there much fishing at Erith in Church Hole?—Yes, I have seen 40 boats together.

2336. When did that come to an end?—I suppose about 14 years since.

2337. Where did they go to?—Down below Gravesend.

2338. Were there any bait or worms found in the upper part of the river formerly?—Yes, from Erith to Woolwich.

2339. What kind of worms were they?—Mud worms we call them.

2340. Do you know yourself where any are found now?—None at all this side of Woolwich.

2341. What do you mean by this side of Woolwich; do you mean between Erith and Woolwich?—Yes.

2342. That is to say, down the river from Erith to Woolwich?—Yes.

2343. Can you tell us up to what time they got worms out of the mud?—I have seen them 9 or 10 years back. I have seen thousands of starlings on the mud feeding on them.

2344. And you say there are not any now?—No.

2345. How far are you in the habit of going down the river?—I am in the habit of going down the river to Gravesend.

2346. In going up and down the river do you notice any alteration in the colour of the water?—Yes, a good deal.

2347. What is it like?—Filth; black.

2348. When do you specially note it; at any time of the day or tide?—Yes, about half tide, half ebb.

2349. Is there any stench with it?—Yes, a good deal.

2350. A very bad stench?—Yes, a good deal at times. When you are rowing a boat through it, it is like a lot of mud.

2351. Of what part of the river are you speaking now?—In Halfway Reach.

2352. In coming down the river can you say how far this sewage goes out with the ebb tide?—Yes, I have been driving bottles from the sewerage three years back to see how far it did extend.

2353. (*Sir John Coode.*) On your own account?—No, I had been engaged to do it. They were gallon bottles.

2354. (*Mr. Beaumont Morice.*) You put these gallon bottles in and see how far they will go down from the outfall?—Yes.

2355. (*Sir John Coode.*) Have you been filling bottles or setting them afloat?—Putting them afloat.

2356. Not filling bottles with the sewage water?—No.

2357. (*Mr. Beaumont Morice.*) How far did they go down?—Down to the "Ship and Lobster."

2358. That is just below Gravesend, is it not?—Yes, They went down as far as that on a strong spring ebb and westerly wind.

2359. (*Sir John Coode.*) Did you always set them afloat at the same period of the tide?—We only went once; only one day. We went from the sewerage on a spring ebb tide on the high water.

2360. I understood you to say that you had been doing it for a considerable period?—No, only one day.

2361. You set them afloat at high water?—Yes; at high water from the sewerage.

2362. (*Mr. Beaumont Morice.*) And they went down to the "Lobster"?—Hardly down to the "Lobster"; to the lower part of Gravesend. They hired me from Greenwich. I do not know who they were.

2363. Of course, from going up and down the river, you know the shore of the river?—Yes.

2364. Along Halfway Reach and around Erith Bight what sort of stuff is there on the north shore?—Nothing but filth; it is not mud at all.

2365. Is there much of it?—Yes, a good deal.

2366. Is there much stench from it?—There is not much stench, but it is grease. It is not mud, it is filth.

2367. Has there been much increase of it during the last few years?—Yes, I think there has; a good deal.

2368. Do you know the Bight, right round from Church Hole down to Erith Causeway?—Yes.

2369. Is there much along there?—Yes, that is just where it is.

2370. Do you know the Causeway?—Yes, I remember when I had only three steps to go in a boat at low-water time; and it has been lengthened 60 feet since that; and now you cannot get within five boats' length at spring ebbs.

2371. Is the stuff alongside the Causeway mud?—No; it is not mud at all.

2372. Is there much depth of it?—Yes; there are four or five inches of this filth. There is plenty of mud underneath that.

2373. Have you ever felt any bad effects to your health from this?—No, I never have.

2374. Does it never make you sick or faint?—No.

Cross-examined by Mr. Norman Bazalgette.

2375. You told us that all the mud worms had disappeared between Erith and Woolwich during the last 9 or 10 years?—From Erith to Woolwich.

2376. What have they done above Woolwich?—I cannot tell.

2377. Have you ever seen any of them above Woolwich?—No.

2378. What made you look for them below Woolwich; you are not a fisherman, are you?—No, I never looked for one. I looked for the birds feeding on them.

2379. What birds?—Starlings. Where you see them, there are plenty of mud worms.

2380. You tell us that you have been "driving bottles;" when did you "drive bottles"?—I think it is three years since.

2381. Was that for Captain Calver?—Well, I cannot tell you.

2382. Who employed you to drive the bottles?—A gentleman at Greenwich employed me; I could find out who it was.

2383. You floated these bottles down to below Gravesend; did they stay at Gravesend or what became of them then?—I took them in the boat and brought them home again.

2384. You did not try how far they would go back?—We never tried it back again.

2385. Where did you start from?—From the sewerage.

2386. That is at Crossness. From there to the "Lobster" is about 13 or 14 miles, is it not?—A little more, I think.

2387. How long were they going down there?—About six hours, I think.

2388. You say your bottles took about six hours to go from Crossness or Barking to the "Lobster"?—We did not go so high as Barking. I do not say they took exactly six hours—the whole ebb tide.

2389. They went down with the ebb tide at any rate to the "Lobster"?—Barely to the "Lobster."

2390. You say that the deposit against the Causeway at Erith is not mud at all; what is it?—All along it is nothing but filth; it is not mud.

2391. How do you know it is not mud?—Because I have experienced it in the boat.

2392. Did you take it in the boat with you?—Yes; I haul ropes in and out of my boat, I do not haul mud in. I haul grease in.

2393. Then it is all grease, is it?—Yes. I will show it you now if you go down to Erith.

2394. Do you know the sewers at Erith that discharge into the river by the Causeway?—There are one or two, I think; but I have nothing at all to do with them.

2395. But you know that there are sewers there?—Yes, there are several; there are four or five there, I know.

2396. (*Chairman.*) That discharge into the river?—Yes.

2397. (*Mr. Norman Bazalgette.*) You say that this deposit smells bad?—Coming from the sewage it does.

2398. Is there any of the deposit down in that part of the river that does not smell, say in Halfway Reach?—Not the water, I do not think.

2399. The water does not smell?—I never smelt it. I smell the stench ashore, but not in the water.

2400. The smell is on the shore, you say?—Yes, the smell is on the shore, from the sewage in the water.

2401. Is the smell on the river as well as on the shore?—What from?

2402. Is there any smell on the river or is the smell on the shore; which is it on, either or both?—I do not understand what you mean. There are plenty of smells up and down the river, but you do not smell any smell in the water, only from the sewage.

2403. Can you distinguish the smell that comes from the water from the other smells?—Yes, it comes up like smoke. The colour of the water is enough.

2404. Which smells the worst, the smell which you get from the air or the smell from the water?—The smell from the water.

Re-examined by Mr. Beaumont Morice.

2405. You get smells from the factories up and down the river?—Yes; that is only for a little time.

2406. Is that anything like what you have been talking about,—the smell from the sewage?—No,

2407. The sewage smell is quite different?—Yes, quite different altogether.

2408. There is no mistake about that?—No.

2408*a*. You have been asked about the drains and sewers going into the river from Erith; do you know much about that?—I do not know much about the sewage at Erith. I have lived there 10 years, but I never took that notice. I have been on the water all my lifetime. I said I knew of four or five.

2409. What do you mean by sewers?—Only drains from butchers and one place and another.

*Mr. W. Hoskins.*

17 Nov. 1882.

Examined by the COMMISSION.

2410. (*Professor Williamson.*) Do you perceive this smell of the sewage at this time of the year?—Yes, at any time.

2411. Do you mean to say that you perceived it to-day?—No, I have not been there to-day.

2412. Would you perceive it in winter as well as in summer?—Not so strong in the winter.

2413. But still you do perceive it in the winter?—Yes.

2414. (*Sir John Coode.*) You seem to know about these butchers' drains at Erith. What becomes of the sewage of the population of Erith?—I do not know. I do not study that at all. I know four or five there.

2415. Public sewers?—Yes.

2416. (*Colonel Ewart.*) When you are passing there do you see these sewers discharging at Erith?—If they kill a bullock, or anything like that, they will discharge.

2417. (*Sir John Coode.*) We shall have some evidence, I suppose, as to how the sewage of Erith is disposed of. How does that get into the Thames?

2418. (*Mr. Beaumont Morice.*) There is one sewer for Erith some distance below the pier.

2419. (*Chairman.*) This witness cannot be expected to give us much information about the sewage.

2420. (*Mr. Norman Bazalgette.*) I do not quite admit my learned friend's version about the sewage of Erith; and I think if there is any doubt about it it would be as well to recall the surveyor of Erith. We shall be prepared with evidence on the point.

2421. (*Mr. Beaumont Morice.*) I am willing to do anything that the Commission desires on that matter; but I may perhaps say, as a resident, that there is one drain below Erith, and a large portion of Erith is drained into cesspools.

2422. (*Mr. Norman Bazalgette.*) The natural way of clearing this up would be to recall the surveyor of Erith, who would put in plans.

2423. (*Chairman.*) Mr. Morice will take his own course about it. (*To Mr. Beaumont Morice.*) Is your surveyor here?

2424. (*Mr. Beaumont Morice.*) Not to-day, but I can have him here on the next occasion if the Commission think fit.

2425. (*Sir John Coode.*) We seem to be agreed that it should be in evidence from the surveyor or some competent witness.

2426. (*Chairman.*) It is suggested that the Erith sewage does contribute in some measure to the general foul state of the river, and one would like to see exactly how the matter stands.

2427. (*Mr. Beaumont Morice.*) It was only on the last occasion that Mr. Bidder mentioned that this was a point that he would bring before the Commission.

2428. (*Sir John Coode.*) If you will recall the surveyor, that will meet the case.

The witness withdrew.

*Mr. C. Faulkner.*

Mr. CHARLES FAULKNER called in; and examined by Mr. BEAUMONT MORICE.

2429. You live at Erith?—Yes.

2430. Have you lived there for a long while?—Yes.

2431. What are you?—To tell you the truth, I am anything. I am a contractor to do anything.

2432. How many years have you lived at Erith?—I have lived in Erith about 63 years.

2433. During this time you have known a good deal about the river Thames, have you not?—Yes.

2434. Has your work chiefly been connected with mud?—Yes, mud work on and off; and I follow it now.

2435. What was the state of the mud in the river 15 or 20 years ago?—I can speak to 45 years back, but 20 years ago it was a pure, salty smell.

2436. How long did that continue?—I should say from that time it went on in that way for four or five or six years.

2437. When did it alter, if it did alter?—It began to alter about 15 or 16 or 17 years ago.

2438. How did it alter?—There were bad smells.

2439. Anything else?—No, nothing else; only bad smells, and of course it drove the fish away from us; we have no fish now.

2440. Was there fishing at that time?—When I was a boy I have been trawling with a fisherman and got plenty of fish off Erith and above Erith and below Erith.

2441. And now you say the fish have been driven away? What is the water in the river like now off Erith?—The water of course is purer now than it has been for a long while through the rain water, but in summer time if you go and work in the mud you have to wash your hands four or five times before you get the smell out of them.

2442. You have had a good deal to do with the mud about there?—I have.

2443. What is the mud like now off Erith?—Black mud; you might say it smells more like night-soil than anything else.

2444. Is there much of it?—It is "created" on the shore at Erith. I should say a foot and a half thick.

2445. This night-soil?—This black stuff that comes down.

2446. (*Sir John Coode.*) When you say "created," I suppose you mean "accumulated"?—Yes.

2447. (*Mr. Beaumont Morice.*) Has that been increasing in the last few years?—Yes; I should say from 20 years ago up till now. We have not so much water there by the ballast wharves by 8 to 10 feet. There is this black stuff.

2448. Whereabouts are the ballast wharves?—You know the "Corinthean Clubhouse" and the old Erith pier; it is between there and all along below the pier.

2449. (*Sir John Coode.*) You are speaking now of the old causeway, I suppose?—Yes.

2450. (*Chairman.*) It is between those two places that the mud has accumulated?—Yes, I should say from 8 to 10 feet.

2451. (*Mr. Beaumont Morice.*) The Corinthian Yacht club-house is in Church Hole, is it not?—Yes.

2452. You know the river from Church Hole down to the Causeway?—Yes.

2453. Is there this stuff that you have been talking about all along there?—Yes.

2454. That is in the bight?—Yes, in the bight.

2455. Is there much tide in there?—No, a slack tide.

2456. There is a sort of eddy-tide sometimes, is there not?—There is an eddy-tide. There is more eddy-tide now than I ever knew, and I have been at the waterside over 55 years.

2457. Does this stuff settle there at all?—This stuff settles there.

2458. (*Chairman.*) There is no question about this, I believe. I think it has been admitted that there is a large accumulation of stuff there.

2459. (*Mr. Beaumont Morice.*) But it is not quite admitted in the sense that I want it admitted, namely, that the stuff is sewage.

2460. (*Chairman.*) What is admitted is, that there is a large accumulation of matter; and therefore we may take it very shortly from this witness that there is an accumulation; but what that accumulation is, he perhaps cannot tell us.

2461. (*Mr. Beaumont Morice to the witness.*) Can you tell us what this stuff that is accumulated is like?—It is black, and seems a regular settling like what you may call closet stuff settling.

2462. Is there any stench coming from that?—Yes, in the summer-time very much. You do not smell it now, but I have looked after Price's and Harvey's oil works, where the barges lie at the present time for eight or ten years——

2463. (*Sir John Coode.*) Are you the contractor for barging from those works?—No; I am contractor for laying the barges level.

2464. (*Mr. Abernethy.*) For the berths?—To lay the berths for the barges.

2465. (*Mr. Beaumont Morice.*) You have to clear out the mud for those berths?—Yes.

2466. Have you had more difficulty in clearing out the mud from those berths lately than you used to have?—Yes, I have more now, and I have actually

at half ebb tide seen the stuff from, you might say, the closet come down by there whole, not washed to pieces.

2467. Has that happened several times?—I have seen it several times. Sometimes I do not have to go there once in a month, and sometimes I go there two or three times in a month, but I always like to catch the tide when the tide is running down and then it sweeps all that stuff away.

2468. You have found this stuff increasing in the last few years more than ever?—Yes, it has increased from 8 to 10 feet there in the last 18 or 20 years.

Cross-examined by Mr. Norman Bazalgette.

2469. I suppose I need not ask you whether you enjoy good health as a general rule?—Well, I have pretty good health.

2470. Have you any family?—I have one or two.

2471. Do they enjoy pretty good health?—They are away; one is at Sydney and one is at Woolwich.

2472. And you have all your life enjoyed pretty good health?—Yes.

2473. You have not enjoyed worse health during the last 20 years than you did before?—Yes, I have.

2474. What has been the matter with you?—I am troubled with the gout sometimes.

2475. (*Sir John Coode.*) I do not think you have told us where you live?—I live at Erith in West Street.

2476. Near the water side?—Yes, and I am obliged to linger there.

2477. Near the river side?—Yes.

2478. (*Mr. Norman Bazalgette.*) You told us, I think, that you got a great accumulation of mud on the ballast wharf?—Yes, round in the bight.

2479. Do you know the ponds on the land at the back of the ballast wharf; do you recognize these ponds (*showing a plan to the witness*)?—I recognize one of them.

2480. (*Chairman.*) Where do you suggest that the pond is?

2481. (*Mr. Norman Bazalgette.*) At the upper ballast wharf.

2482. (*Witness.*) There is no pond at the upper ballast wharf.

2483. Is there one at the lower ballast wharf?—No.

2484. Where is the one that you know of then?—There is one between the upper ballast wharf and the church—what we call Running Water Pond.

2485. Do you know of any ponds for keeping the mud away, ponds that stand full when the water is up and when the tide falls the gates are open and then the mud is washed away?—We call them reservoirs.

2486. Do you know the reservoirs?—Yes.

2487. How many are there?—Two; one at each wharf: one at the upper side of the upper wharf, and one at the lower side of the old wharf.

2488. Will you shortly describe to the Commission the objects for which those ponds are used?—They fill with the tide, and there is a flap that opens and when the tide goes back that flap shuts and keeps the water in the reservoir; and when the tide is down they pull up a sluice-gate and let it all run out.

2489. The object of that is to wash away the mud that has accumulated?—Yes.

2490. How many years have these reservoirs been in existence; ever since you were a boy?—No.

2491. How many years?—I can tell you within a little. It is not above 15 or 16, or I might say 18 years, since the new reservoir was built there.

2492. How long have the old ones been there?—There are two new ones. The old ones are done away with.

2493. (*Chairman.*) The question is this: when were those two reservoirs which you are speaking about made?—I should think about 18 years ago.

2494. (*Sir John Coode.*) Are those the old reservoirs?—No, not the old ones.

2495. (*Mr. Norman Bazalgette.*) When were the old ones first established there?—I have known four in my time; but when the old ones of all were made, I was only a lad.

2496. The old ones were used for the same object as the new ones are used for, were they not?—Yes, I suppose so.

2497. Then that particular place, Erith Bight, has always been subject to accumulations of mud?—No, nothing like it has been the last 18 or 20 years.

2498. But still we have the fact that that old reservoir existed when you were a lad for the purpose of clearing away the mud?—The old one was just to keep the beds clean.

2499. (*Chairman.*) When you were a boy there was an old reservoir there?—There was no old reservoir at that time. When I was a boy I knew nothing about where the reservoir was; but I have helped to make three in my time, one at the old wharf at the lower side.

2500. When was that made?—That was made about 28 years ago.

2501. Is that the oldest reservoir that you recollect there?—That is the oldest of the new ones.

2502. But there was an older one still?—Yes, there was a bit of one there.

2503. When you were a lad?—When I was a young man.

2504. Did not that old reservoir, which existed when you were a young man, receive the tide when the tide made, and was it not opened when the tide fell again?—Of course it fed itself.

2505. And the sluices were opened?—Yes.

2506. That is when you were a young man?—Yes.

2507. Forty years ago?—Yes.

2508. Fifty?—Well, I might say 50.

2509. (*Mr. Norman Bazalgette.*) What is your age?—I am in my 67th year.

2510. You said that there was something, I do not know whether it was the mud or the water, that you could not smell now; were you referring to the mud or to the water?—I tell you that the water is purer now than it is in the summer-time.

2511. When did the water last smell?—I am not always by the water side.

2512. But when did you last smell it so as to find it offensive?—The last time I was using my hands in the mud is about a month ago; and you are obliged to wash your hands. I look after Price's Oil Works and Harvey's Works, and if you go and handle the mud there, you smell it.

2513. I am very much obliged to you for that information, but you have not answered my question yet. When did you last smell the water so that it was offensive to you?—I do not smell the water. It is about a month ago since I was in the water with my water-boots on.

2514. I thought you told me it was the mud that you smelt then?—Mud and water.

2515. I presume that you occasionally walk along the banks of the river?—Sometimes.

2516. Have you ever smelt the water from the banks of the river?—Yes.

2517. When did you last smell it so that it was offensive to you?—Very likely you would go two or three weeks, or four or five weeks without smelling it, according to how the wind is.

2518. And then how long do you smell it for?—Till you get away from it.

2519. You have given me a good deal of general information; can you give me approximately any date when you last smelt it in that way?—I do not put these things down, I am obliged to put up with it as I go along. I do not put the dates down.

Re-examined by Mr. BEAUMONT MORICE.

*Mr. C. Faulkner.*
17 Nov. 1882.

2520. You know well enough that you smelt it?—I do.

2521. (*Sir John Coode.*) Were these old reservoirs of which you told us used for the same purpose as the new reservoirs, which you said you assisted in making; that is to say, for the purpose of sluicing the mud from the foreshore?—Yes.

2522. Why were the old reservoirs abandoned, and new ones made?—The land was put out for other purposes.

2523. But they were used for sluicing the mud from the foreshore?—Yes.

The witness withdrew.

Mr. WILLIAM HARLING called, and examined by Mr. BEAUMONT MORICE.

*Mr. W. Harling.*

2524. You live at Erith?—Yes.

2525. And I believe that you have worked at the ballast wharves for about 20 years?—Yes.

2526. Have you had a good deal to do with keeping the place clear of mud?—Yes.

2527. What was the river about there like when you first worked there 20 years ago?—The water was clear, and you could catch plenty of fish there at that time. I have been in fishing boats when they caught a hundred bushels off Erith on a Sunday morning.

2528. (*Sir John Coode.*) Not one boat?—No; 20 or 30 boats lying there.

2529. (*Mr. Beaumont Morice.*) It was a good fishing place?—Yes; there were plenty of shrimps, flounders, and eels.

2530. And whitebait?—Yes, and whitebait.

2531. How long did that continue?—It lasted a long while there, catching the shrimps.

2532. How many years ago did the fishing boats have to go away?—They were there all the summer season catching shrimps; not now.

2533. How many years ago is it that they stopped coming?——

2534. (*Mr. Norman Bazalgette.*) We have admitted the fact over and over again that there are no fish to be caught there.

2535. (*Mr. Lumley Smith.*) The important fact is when they ceased to be there.

2536. (*Mr. Beaumont Morice to the witness.*) When did they stop coming?—About 14 or 15 years ago.

2537. Has there been any alteration in the character of the mud that you have been working in?—There is a lot of filth all along the shore, and the mud "creates" that filth in there in the dock.

2538. When did the mud begin to get that filth?—About 12 or 14 years ago.

2539. Has it got very much worse from time to time lately?—It has got worse lately.

2540. What is it like?—It is a greasy kind of stuff.

2541. Is there any stench with it?—Yes, it all sticks on your finger-nails when you try to wash it off.

2542. What is the stench like?—"Greasified;" and also like your own manure in great lumps all along the sides of the dock as big as your fist.

2543. Lumps of what?—Dung, I call it; closet stuff,—what floats down the river.

2544. You clear the place out where the ships come in?—Yes.

2545. Ships come alongside the wharf and take in ballast?—Yes.

2546. And you have to keep this place clear for them in order to come in?—Yes.

2547. Have you felt any ill effects from this?—Yes, I am under the doctor's hands now; Mr. Jesset is my doctor. Every time I go into that dock I am forced to go to Mr. Jesset, and he allows that it is from the stench from the mud.

2548. Mr. Jesset is the medical officer of Erith, is he not?—Yes.

2549. Do you feel sick?—Always sick and "faintified," and very short-breathed.

2550. (*Sir John Coode.*) For how long has that been the case?—For the last three or four years.

2551. Did you ever suffer in that way before you took to this line of business?—No, nothing in that way at all.

2552. (*Mr. Beaumont Morice.*) Has this state of things, this filth, got worse during the last five years?—Yes, it has got worse. There is a great deal of settlement all along on the steps as you get up the ladders out of the ships.

2553. When the tide goes down, do you find any of this stuff settles there?—Yes, it settles along on the bank.

2554. What is it?—It is black stuff; it is not mud.

2555. Is there any stench from it when it is left there by the tide?—Yes; great lumps of cork and bits of stuff all bound round it. You can squeeze it to pieces and see what it is.

2556. What is the color of that stuff?—Black.

2557. You know the reservoirs for flushing the dock?—Yes.

2558. Have they to be constantly worked now?—Yes, every tide; to wash the mud and filth out.

2559. Do you find that there has been more accumulation of this mud in the dock in the last few years than there used to be?—Yes, and it settles more in the reservoirs.

2560. (*Chairman.*) What dock are you speaking of?—Where the ships come in and lay alongside of the quay, and then there is a reservoir to let the water out and drive the filth out.

2561. You say that every time you go to the dock you suffer. What dock do you mean?

2562. (*Mr. Beaumont Morice.*) What the witness refers to is what we should call a mud berth alongside a staging which is a ballast wharf.

2563. (*Witness.*) Yes.

2564. (*Sir John Coode.*) Is it a basin, or is it a jetty projecting from the shore?—It is not a jetty, it is a gut-way.

2565. It is a creek with a sort of wharf alongside of it?—Yes.

2566. When you speak of the time when you go into the dock, you mean every time you go down for the purpose of clearing away the mud; is that so?—Yes.

2567. (*Mr. Beaumont Morice.*) There is a sort of scooped out basin in the mud in which the vessels lie, it is part of the Erith bight, is it not?—Yes, it is rubbed out from the river side.

2568. There is a lot of mud all round the wharf, is there not?—Yes, and this gut-way is cut through the mud, and then there is a reservoir inside which comes right out and washes the mud out.

2569. But there is no dock wall or anything of that kind?—No.

Cross-examined by Mr. NORMAN BAZALGETTE.

2570. I think you told us that the fishing boats left Erith about 14 or 15 years ago?—Yes.

2571. How do you fix that date?—According to my recollection of the time.

2572. By what circumstances do you happen to recollect so exactly?—Because I used to go off there and have some shrimps off the boats.

2573. You recollect that 14 or 15 years ago you used to go off and have shrimps?—I could not say exactly, but to the best of my judgment it was about that time. I never booked it or anything of that kind.

2574. You know these reservoirs at the ballast wharves?—Yes.

*Mr. W. Harling.*

17 Nov. 1882.

2575. Have they to be very frequently cleared out?—Yes.

2576. What is taken out of them?—Mud and "slurry," black stuff; I cannot say what it is.

2577. The water of the Thames is admitted into these reservoirs, stands in it for a certain time, and then the suspended matter becomes deposited?—It is let off every tide.

2578. How often do you say that they are cleared out?—Every other week, according as the tide suits.

2579. Did you say that every time you go into the dock you have to go and see your doctor?—I have to go and see Mr. Jesset.

2580. Does anybody else work in the dock with you?—One of them does not go to the doctor and one of them does.

2581. Every time you go?—Not every time I go.

2582. Previously to the time when this began, did you enjoy pretty good health?—Yes, as good as I wish to enjoy.

2583. How long has your mate, who has been ill been working at the dock?—He has been working at the dock about six or eight years.

2584. And how long has he been taken in this way?—About two or three years, I suppose.

2585. And previously to that he also enjoyed pretty good health, as far as you know?—Yes, and he is in pretty good health now.

2586. (*Chairman.*) You go to this work about once a fortnight?—Yes, when the tide suits.

2587. (*Mr. Norman Bazalgette.*) Once a fortnight for these last three or four years you have gone regularly to the doctor's?—Yes, pretty nearly every time.

2588. Do you pay the doctor?—I belong to a club.

2589. I presume that you pay the annual subscription to that club and they give you medical advice?—Yes.

2590. Would the books of that club show how often you have been there?—No; only a certificate from the doctor if you lie up; that is all.

2591. You have not been so ill that you have had to lie up?—Only twice.

2592. And what were you laid up from on those two occasions?—The doctor allowed that it was from the stench of the mud.

2593. What did he describe your illness as being?—I do not know.

2594. (*Chairman.*) Is Dr. Jesset here to-day?—No.

2595. (*Mr. Norman Bazalgette.*) Do you remember what the doctor gave you for your illness?—No.

2596. Did he give you anything?—Yes, white stuff in a bottle; that is all that I know.

Re-examined by Mr. Beaumont Morice.

2597. What is the name of your mate?—Clarke.

The witness withdrew.

Mr. Henry Clarke called in; examined by Mr. Beaumont Morice.

*Mr. H. Clarke.*

2598. Do you live at Erith?—Yes.

2599. And have you been working at the ballast wharves there?—Yes.

2600. For how long?—I have been at work for Mr. Parish all my life.

2601. (*Chairman.*) If anything turns upon the health of these people it is the doctor who could tell about it much better than the men themselves.

2602. (*Mr. Beaumont Morice.*) Yes sir, but I have to ask them whether they have had any illness at all.

2603. (*Chairman.*) The doctor will tell us that. However, we will take it very shortly.

2604. (*Mr. Beaumont Morice to the witness.*) You are the mate of Harling?—Yes.

2605. And you occasionally go and work in this mud?—Yes.

2606. (*Chairman.*) Do you find any ill effects from it?—Yes.

2607. What effects have you felt from it?—A nasty, faint, sickness.

2608. Has that been more lately?—Yes; more than when I first went.

2609. What sort of stuff is this mud?—Black, nasty filth, more like the stuff from the human body than anything else, settles on the top.

2610. Is there any stench from it?—Yes.

2611. How often do you go down there?—On spring tides; you cannot go down on ebb tides.

2612. How often have you felt any ill effects from it?—Almost always when we go; and if we do not have our breakfast before we go, we do not want any when we come back.

2613. Has there been any alteration in the character of this stuff in the last few years?—Yes; it gradually "creates" more.

2614. And gets worse?—Yes.

2615. And you say it is not mud, it is filthy stuff?—Yes, it is filth.

2616. Are you under the doctor's hands now?—No, I am not.

2617. When was the last time you went down to this place?—The last springs, about a fortnight ago.

2618. Used you to be laid up from it?—No, I never was laid up through it.

2619. Used you ever to suffer from it till recently?—No, not until lately.

2620. And you say that lately it has got worse?—Yes.

2621. Is there more of this stuff as well as its being worse in kind?—Yes, there is more of it than when I first knew it and took notice of it.

Cross-examined by Mr. Norman Bazalgette.

2622. I suppose you know the reservoirs in the ballast wharves?—Yes, I do.

2623. Can you tell us whether those reservoirs are cleared out more often now than they used to be?—They are.

2624. How much oftener in your time?—When I first started they were not cleared out above two or three times a year.

2625. How long ago is that?—About six years.

2626. How often are they cleared out now?—Once in every fortnight.

2627. The next wharf to your ballast wharf is a dung wharf, is it not?—It is.

2628. What is the process of loading and unloading this dung at that wharf?—I have never done any of it there.

2629. Have you seen it being done?—I have.

2630. Is it loaded and unloaded in very considerable quantities?—Yes, there is a great quantity at times; not always alike.

2631. (*Chairman.*) You have seen them unloading it?—I have seen them as I passed by. I never was amongst it.

2632. You never took any particular notice of it?—No.

2633. (*Mr. Norman Bazalgette.*) It is brought down in barges, and then unloaded and taken away in carts?—Yes.

2634. That is not a particularly pleasant operation, is it, at the next wharf to you?—It is next to it, that is all.

2635. Does it smell nice?—At times; but that

*Mr. H. Clarke.*

17 Nov. 1882.

is not very often because it is not there long at a time.

2636. I presume that at other times it smells nasty?—Yes.

2637. (*Chairman.*) Have you been obliged to go to the doctor?—Yes, I have been and got a bottle of medicine, and, of course, that has put me right again for a while.

2638. How often have you had to do that?—Not very often.

2639. Twice?—Three times or more than that.

2640. That would be four times?—Yes.

2641. (*Sir John Coode.*) Since when?—I suppose the time when I first went to the doctor would be about two years ago.

9642. (*Chairman.*) Did you go to Dr. Jesset?—Yes.

The witness withdrew.

Adjourned to Tuesday next at 1 o'clock.

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# SIXTH DAY.

## Tuesday, 21st November 1882.

PRESENT:

Sir P. BENSON MAXWELL IN THE CHAIR.

Sir John Coode, Mem. Inst. C.E.
Colonel C. B. Ewart, C.B., R.E.
François de Chaumont, Esq., M.D., F.R.S.
Thomas Stevenson, Esq., M.D.
James Abernethy, Esq., F.R.S.E., Mem. Inst. C.E.
William Pole, Esq., F.R.S., *Secretary.*

Mr. William Gatward called in, and examined by Mr. Beaumont Morice.

*Mr. W. Gatward.*

21 Nov. 1882.

2643. I believe you are a constable stationed at Barking, are you not?—Stationed at Barking Creek.

2644. How long have you been stationed there?—12 years.

2645. How far is the northern outfall from your station?—About 700 yards.

2646. Can you tell us what is the state of the river at your station?—Sometimes it is very bad, especially after a hot day. Then it smells very bad indeed.

2647. In what other way is it very bad besides that?—There is a great quantity of refuse always left on the shore, which smells,—fat, and bullock's lights; and the water is quite black when the sewage is coming out, and after a hot day it smells very bad, you can hardly endure it at all; it makes you feel quite sick.

2648. Have you ever felt any sickness from it?—I have at times, when standing on the wall.

2649. Does this last long, at any time during the day?—During the time that the tide is going down, and after the tide has gone down. The heat of the sun on the mud will produce it.

2650. What sort of stuff is that mud?—Almost black.

2651. Is it mud?—It is greasy, slimy stuff; it looks like mud.

2652. Can you tell from where you are at what time the sewage comes out of the outfall?—Yes; directly they open the sluice I can see it run into the river; directly they lift the slacker.

2653. Can you tell with regard to the time of high water, at what time it comes out?—Yes; I have seen it come out before high water, and I have seen it running up a good deal after low water, after the tide has been flowing.

2654. (*Sir John Coode.*) But do you mean to say that you have seen it running out of the sluice after low water?—Yes.

2655. (*Chairman.*) Sometimes before high water?—Yes.

2656. (*Mr. Beaumont Morice.*) Of course if it is before high water it would go up the river?—It would go up the river then.

2657. Have you seen that on more than one occasion?—On several occasions I have seen it, but I have not the dates.

2658. When you see it after low water do you see it coming out of the sluice from where you are?—Yes, you can see it run right down the gut in the mud into the water; and you can always tell where it is by the colour of the water.

2659. I think at your creek you have a causeway, have you not?—Yes.

2660. What is the state of that causeway on the ebb tide, when the tide has left it?—Sometimes it is very slippery, and there is a great quantity of mud and slime and stuff left on it as the tide goes down.

2661. Is there any smell at all from it?—A very great smell.

2662. What kind of smell?—I do not know that I can explain the smell, but it is a very faint, nasty, sickly smell.

2663. (*Mr. Bidder.*) Is this on the mud?—On the causeway; what is left on the causeway.

2664. (*Mr. Beaumont Morice.*) Is that the causeway at Barking Creek?—Yes, it is a causeway made of wood which runs down to low-water mark.

2665. Have you ever seen any dead bodies taken up?—Yes, I have had the handling of a great quantity of bodies since I have been there at different times. I had the handling of the whole of the "Princess Alice" bodies that were landed at the creek to the number of 34; and at other times I have had bodies that have been picked up of people that have been drowned up the river and have floated down there and been brought ashore by different people.

2666. Will you tell the Commission in what state you found those bodies?—In a most beastly state they were. They had not been in the water above two days some of them; some a little longer; but they smelt so that you could hardly bear it.

2667. Was there any deposit on them?—Yes, amongst the clothing there was a great quantity of slime and filth; and when they had lain a few hours the smell nearly knocked you backwards when you went to them.

2668. Have you ever had to do with bodies out of any other water except the Thames?—No, I never had charge of bodies out of any other water, but I have seen them.

2669. What have you seen?—I never saw any other bodies in the same state as those are that come out of the Thames.

2670. What other ones have you seen?—I have seen some out of the river Lea.

2671. Is that near your place?—No; that was before I went down there, before I was in the police.

2672. And you say that they were in a different state from those which you find in the Thames?—A great deal different; they looked fresher; they would lie for some days in the water and they would not be in the same state as they are in after being a couple of days in the Thames.

2673. Do you know the mud along the foreshore round by Barking?—Yes.

2674. Is there much of it?—Yes; there is a great scope of mud there.

2675. Of what character is it?—The top of it is greenish.

2676. (*Mr. Bidder.*) Will you point out on the map where this place is?—It is there (*pointing it out*). I am stationed within 700 yards below the outfall.

2677. (*Mr. Beaumont Morice.*) Do you know the character of the mud along the foreshore there?—I do not know about the character of it. I know it is very black.

2678. What is it like?—It is almost like filth; it is filth.

2679. (*Mr. Bidder.*) As to the character of the mud, the evidence of chemists will be much more reliable than that of a policeman.

2680. (*Mr. Beaumont Morice.*) I am not asking him as to the character of the mud, but as to its appearance.

2681. (*Witness.*) It is not like other mud that you will find in other places; it is black.

2682. Have you ever had anything to do with any of the fishing in the river?—Yes; I have seen plenty of fish coming there, but they are all dead, or nearly so; they seem in a stupified state. I have seen plenty of eels there. This last week plenty of eels have come down with the fresh water through the rains, and as soon as they get there they lie dead on the stones.

2683. (*Chairman.*) You saw the eels lying dead?—I saw one hundredweight picked up in one morning on the stones at Barking Creek.

2684. (*Mr. Bidder.*) In the creek?—No, not in the creek, but in the river; on the stones along the river shore.

2685. (*Sir John Coode.*) How far from the outfall?—Some would be 700 yards, and some further; some perhaps half a mile down the shore, towards the Horse-shoe corner, getting down towards the southern outfall.

2686. Did you see any near the outfall?—No; the creek runs between me and the outfall. I cannot get up to the outfall.

2687. (*Mr. Beaumont Morice.*) Have you ever seen anything of the kind before?—Plenty of times. About this time of the year, when there are heavy rains, eels come down and they lie half stupefied upon the stones. I have never seen any what you may call live fish there, not but what you could go and pick them up.

2688. Have you ever smelt this sewage smell at any other part besides the exact place where you are stationed?—Yes; I often go down the river in a boat, and sometimes you cannot bear the smell as you go down the river; you are glad to run the boat ashore and get out of it. Sometimes the smell is so bad you cannot stand it.

2689. Is it part of your duty to go up and down the river in a boat?—When I go down the river in a boat I go for my own pleasure.

2690. How far have you gone down the river in a boat?—Down as far as Gravesend.

2691. Have you ever seen any fat on the river?—Yes; you can see that every tide. There are seven men who get their living there pretty well, by skimming the river and getting the fat off it and melting it down.

2692. That you know?—That I know. That is what they called the Thames mud butter.

2693. Do you know how they do it?—Yes; I have been aboard the barge that those men have, and seen them melting the fat down that they got off the river. First of all they have a boat with a well in it, and they fill this boat with fat and let the water into it, and wash it, and all the fat floats on the top and the filth goes out from underneath the bottom of the boat, and it is handed from there into a large tub with reeds and wire put across it, and the steam is turned on, and the steam goes through the fat and melts it. It then comes out in a tub below, and they put a certain quantity of acid with it which causes all the dross out of the fat to go to the bottom, and then the fat is sold for lubricating purposes. They tell me it is made into dripping, but I do not know that myself.

2694. Have you ever seen any solid lumps of sewage floating about?—Yes, I have seen round balls of hard fat floating about, and I have seen great lumps of lights floating about, and other filth.

2695. Have you noticed that at any particular time of the day or the night?—No, there is no particular time; any time when the sewage is coming out.

2696. (*Sir John Coode.*) Do you mean to say that you have seen these lights coming out of the sewer?—No, I have seen them floating in the sewage. I have never been up there at the time; but I have seen them about 300 or 400 yards away from the sewage.

2697. (*Mr. Beaumont Morice.*) Have you seen that often?—Yes; you will see it every tide almost; but you will see it more particularly after a heavy rain.

Cross-examined by Mr. Bidder.

2698. Where exactly are you stationed; are you below Barking Creek or above it?—I am below the outfall.

2699. Then do you sometimes go along the shore to the outfalls?—No, I cannot go along the shore to the outfalls. I go up in a boat sometimes.

2700. For your own amusement?—Yes.

2701. When you have seen the water coming back out of the outfalls, has that been when you have been up there in a boat?—No, it has been when I have been standing on the wall at the creek.

2702. I forget the exact distance of the creek from the outfall?—700 yards.

2703. Hardly so much, is it?—It may not be quite so much, or it may be a little more: I could not say for certain.

2704. Now be careful, if you please. When was it that you saw the sewage coming out before high water?—I could not give you the dates, but it has been during the summer.

2705. Are you certain that you have seen it?—Quite certain.

2706. In the summer of the present year?—Yes.

2707. Once or more?—Several times.

2708. That you are certain of?—Yes. And once since I was up in the office at Cornhill I saw it running up when the tide was running up.

2709. From your station or from the boat?—From where I was stationed. You can always see from the colour of the water the sweep that it takes round in the water. It was on the 25th of August when I saw that. I put that date down. That is this year; since I was up and gave my evidence at the office.

2710. Can you speak to any other day when you have seen it come out before high water?—No, I never took the date at any other time.

2711. When have you seen it running up after the tide had turned?—That was on the 25th of August.

2712. Do not let us confuse different things. You have said two things; you have said that you have seen the sewage let out before high water; that is one thing; and you have also said you have seen the sewage running up after the tide had turned to the flood?—Yes.

2713. I ask you first when you have seen the sewage let out before high water?—And I say I cannot give the date.

2714. I understand that it was on the 25th of August that you saw it running up after low water?—Yes, after low water—about half flood tide.

2715. Where were you?—Standing on the wall.

2716. Your own wall?—Yes, against the manure factory.

*Mr. W. Gatward.*

21 Nov. 1882.

2717. You were a long way off; how did you see it there; by the colour of the stream?—You could see by the colour of the stream where the sewage was running out. You see it rush out of the outlet into the river, and you can see the tide sweep it up or down.

2718. But you say that you are 700 yards off?—It is about 700 yards altogether from me to the outlet.

2719. It would be going away from you; it would not be passing you?—It would be going up towards Beckton.

2720. And you say that at a distance of about half a mile you can see the sewage in the river and distinguish it from the other water?—Yes, quite plain.

2721. Half a mile off when it is going in the opposite direction?—Yes, quite plain.

2722. How far up the river did you trace it in that direction?—You can see it run up very near as far as Beckton Pier; you can see the different colour in the water.

2723. From your station?—Yes.

2724. How far is that?—Perhaps three quarters of a mile.

2725. Have you any other date on which you have seen the sewage running up after the tide had turned?—No, I never put down any date. I was not aware that I should be called on this job or else I should have done it plenty of times.

2726. What is your particular duty when stationed on that river wall?—My duty is to be there when I am wanted. I have no particular set time.

2727. Have you a beat?—No, I have no beat. There is a little village there of about 60 or 70 houses, and I am stationed there to keep peace and quietness, if I can. Only once a day I go to Barking.

2728. I understand you to say that your observations of the smell in the river have been principally when you have been in a boat for your amusement?—Or standing on the wall. Sometimes if you stand on the wall you can hardly bear it.

2729. The wall that you speak of is just below Barking Creek, is it?—The river runs round it; it is part of the wall that keeps the Creek in its place.

2730. There is no other smell that is at all offensive in that neighbourhood except the sewage?—Yes there is. Some of the factories are very offensive; but it is quite different from the other smell. What you smell from the factories is more sulphureous.

2731. And I understand you to say that you have traced the smell going down the river in a boat for your pleasure?—Yes I have sometimes, as low as Gravesend.

2732. Is it your custom then to go in a boat for your pleasure?—Yes, sometimes.

2733. Rowing, sailing and bathing?—Sailing. I should not like to bathe in it.

2734. Do you know Barking Creek itself?—Yes.

2735. Does a good deal of sewage go down Barking Creek?—There is some turned in at the Town quay.

2736. Is that mud up the Barking Creek rather nasty?—The higher you get up the creek the better it is.

2737. But below Barking is it nasty?—No, not so bad as it is in the river.

2738. But is it bad?—Sometimes.

2739. Is it black?—No, it is not. It is more of a yellow colour.

2740. (*Sir John Coode.*) Does all the sewage of Barking come into this creek?—I believe it does.

2741. About what is the population of Barking?—I should think about 15,000.

2742. (*Mr. Bidder.*) It is a small creek, is it not?—It is about as big a creek as there is on the river Thames; it is not very long.

2743. What is the width of it?—I should think it is 50 to 60 yards across.

2744. Is that at high water?—Yes, at low water there is very little water; you can walk across it at low water.

2745. Have you heard complaints about the smell in the creek?—I have, from the people living at the creek.

2746. They say it is very bad at times?—It is very bad at times.

2747. You know that yourself?—I do.

2748. I suppose you do not know what sewage comes into it above Barking?—I know nothing of my own knowledge, only what I have been told. I have been told that there is none; they have cesspools.

2749. You are quite right in limiting yourself to your own knowledge. I want to fix the position of this causeway exactly, on which you say you have detected a bad smell. You said there was a causeway in Barking Creek where you smelt a bad smell?—It runs into the river; it is not in Barking Creek.

2750. Is it at the corner?—Yes.

2751. Is it on the east or the west side of the creek?—On the east side.

2752. Your side?—Yes.

2753. It is just where the creek comes into the river?—Yes, it is just where the entrance is.

2754. And you have noticed a bad smell there?—Yes.

2755. It is where Lawes' chemical works are?—Yes.

2756. (*Sir John Coode.*) What is about the length of this causeway; it is not a very long affair, is it?—It is about 20 yards long, I suppose. It runs from the wall down to low-water mark.

2757. Towards low-water mark, I suppose, not to low-water mark?—It goes right to low-water mark.

2758. Is the foreshore only 60 yards broad there?—I could not say exactly; but I should not think it is more than that. It runs alongside the jetty.

2759. (*Mr. Bidder.*) Now about one or two other matters that you have spoken about, bullocks' lights for instance, they would be large masses of flesh, I suppose?—Yes, large lumps of lights.

2760. How big?—I dare say as big as my head.

2761. Have you ever seen them come out of the outfall?—No, I cannot say that I have seen them come out of the outfall.

2762. Now about the bodies. The bodies that you speak of, I understand, are principally those that were taken up of people that were drowned when the "Princess Alice" was sunk?—Yes, that was when I had the most; but I have had plenty of others.

2763. Where were they landed?—They were landed at the creek, thirty-four of them.

2764. They had been dragged for, I suppose?—Some floated.

2765. Were some of them found close to the outfall?—No, I do not think they were; they were picked up between the outfall and the creek, those that were landed there that night. The others were most of them picked up on the other side of the river and brought there.

2766. At any rate several of them were picked up between the outfall and the creek?—Yes; I picked up two myself there.

2767. Were they covered more or less with that mud which you see upon the shore?—All their clothes were; and in the morning they were quite black.

2768. Were some of them found on the shore?—I believe so.

2769. Were you very much surprised at their being covered with the mud on the shore?—I was very much surprised at the state the bodies were in, the way they went.

2770. Will you answer my question. Were you surprised at their being covered with the mud on the shore?—Yes, I was.

2771. Having been picked up on the mud. I think inquests were held upon those bodies?—Yes.

2772. Were they seen by medical men?—No, I do not think they were.

2773. Was no medical man called in?—No.

2774. Are you quite sure?—Quite sure.

2775. (*Sir John Coode.*) I do not think you need

follow that. The coroner sat on the bodies, and then adjourned the inquest afterwards to Woolwich, so that they were all sat on together at Woolwich.

2776. (*Mr. Bidder to the witness.*) But you mean to say that no medical man ever saw any of those bodies?—Not those that were brought on shore dead.

2777. (*Mr. Beaumont Morice.*) I think that was so with regard to the bodies; they were all brought over to Woolwich. I happened to be at the inquest and I know that that was the fact.

2778. (*Sir John Coode.*) I take it that the witness means that no medical man saw the bodies at Barking.

2779. (*Mr. Bidder to the witness.*) Were the bodies taken to Woolwich?—Yes.

2780. Who saw them at Woolwich you do not know?—No, I do not know anything about that.

2781. About the eels: where was it that you saw the eels picked up?—Along the shore.

2782. Above Barking Creek or below, or in the creek?—Below the creek.

2783. (*Chairman.*) You said between the two outfalls?—Yes.

2784. (*Mr. Bidder.*) Were any of them picked up in the creek?—No, I do not know of one.

2785. Are you quite sure?—Yes.

2786. What size are those eels?—Some of them would be as long as my arm.

2787. (*Mr. Michael.*) And how thick?—Perhaps as thick round as the bottom of my thumb, weighing about 2 lbs. and some of them as much as 3½ lbs.

2788. When was this?—Last week and the week before.

2789. Is it a common thing to get quantities of eels in that neighbourhood?—Yes, about this time of the year.

2790. Do you happen to know whether there are some paper mills up Barking Creek?—Yes, there is up the river Roding at Ilford.

2791. The river Roding runs into the creek?—Yes.

2792. Are those paper mills in a large way of business?—I think they are.

2793. Do they discharge refuse matter into the creek?—They did at one time, but I believe they do not do so now. There has been a great bother about it.

2794. Do you know the Beckton Gasworks?—Yes, I do.

2795. Have you ever been on that part of the river?—Yes, pretty often.

2796. Have you ever seen any discharge coming from them?—I have seen little pieces dropping out of the pipes after they have loaded a barge with tar; that is all.

2797. Have you never seen any strong smelling discharge coming from them?—No.

2798. Have you ever seen a sewer at the Beckton Gasworks discharging into the river?—No.

2799. Do you know whether there is a sewer there?—I do not.

Re-examined by Mr. Beaumont Morice.

2800. You do not know what there is at Beckton?—No, I do not.

2801. You have been asked about these dead bodies; it is perfectly clear that when they came before you they were drowned, so far as you could see?

2802. (*Mr. Bidder.*) That I will admit.

2803. (*Mr. Beaumont Morice.*) You have been asking the cause of death, that is why I asked the witness the question. (*To the witness.*) As to their being covered with mud, was the mud that they were covered with like what was on the shore?—Just the same.

2804. What sort of stuff was it?—Black slimy stuff.

2805. Was there any difference between the bodies that were brought over from the other side of the river and those on your side?—They had been in the water longer, so that they would be in a worse state.

2806. But as to their being covered with anything like mud, was there any difference?—No; there was no difference.

2807. (*Sir John Coode.*) Do you mean to say that bodies were taken from the other side of the river to Barking?—Yes.

2808. I thought you said that they were taken over from Barking to Woolwich?—Yes, they were first brought to Barking. Thirty-four we had at Barking Creek.

2809. How many were brought from the opposite side of the river?—I could not say exactly; but there may have been ten or fourteen.

2810. Have you any personal knowledge of any other part of the Thames?—No.

2811. You cannot speak as to the comparative condition of those bodies, and of bodies washed ashore in the other parts of the Thames?—No.

2812. (*Mr. Beaumont Morice.*) With regard to the stuff that was found on them, was it found on their bodies or mixed up with their clothing?—Mixed up with their clothing and flesh. You had to take a mop to get it off.

2813. You know the factories; are you clear that the smell from them is different from that of the sewage?—Quite different altogether.

2814. How is it that you can tell the sewage when you see it coming along the river, going up with the flood?—By the colour of the water and the bits of filth that you see floating about on it.

2815. Anything else?—And the smell.

2816. You were asked how far it was off you; would not the flood tide set in rather towards Barking Creek in coming up?—No: it will set off from Barking Creek in coming up.

2817. (*Mr. Michael.*) The other side of the creek?—The other side of the creek.

2818. (*Mr. Beaumont Morice.*) How far would it be off you?—It would be about 700 yards.

2819. (*Chairman.*) You stand upon your wall, as I understand, 700 yards from the outfall, and as the tide rises you say you see the sewage actually come out of the outfall and go up the river?—That is right.

2820. (*Mr. Beaumont Morice.*) And you can see it perfectly from where you are?—Yes, I can see it as perfectly as I can see you.

The witness withdrew.

George Roberts called in, and examined by Mr. Beaumont Morice.



2821. I believe you are an inspector of the Thames Police, stationed off Erith?—Yes.

2822. How long have you known the river Thames?—I have known the river Thames from 30 to 40 years.

2823. How long have you been stationed at Erith?—Just over four years; 4½ years now.

2824. Do you remember the outfalls being made?—Yes.

2825. Can you tell us what was the state of the river before that?—The river was in a very good state, so far as the water was concerned.

2826. (*Sir John Coode.*) Where were you when the outfall was made, because you have been only at Erith for four years?—In the same service that I am now.

2827. But in what district?—I was in the Blackwall district at that time.

2828. Did the portion of the river on which this outfall is situated fall within this district at the time when it was made?—No, not the southern outfall; the northern outfall did.

2829. How long had you known that part of the river before the northern outfall was opened?—20 years previously to that or nearly so.

2830. (*Chairman.*) You are now an inspector of of the Thames police?—Yes.

*G. Roberts.*
21 Nov. 1882.

2831. How long have you been an inspector?—About 13 to 14 years.

2832. Have you during all that time been quartered in the lower part of the river?—No, I have been all over the river. I have been up this way towards Putney.

2833. Then before these 13 or 14 years what were you?—I was a constable.

2834. When did you enter the service?—I entered the service in the early part of 1860.

2835. Then from 1860 to the present time you have been on the Thames as a constable or inspector?—Yes. I was, previously to that, on the Thames in the Customs service.

2836. (*Sir John Coode*). Did your duties as a custom-house officer call you frequently over this part of the river?—Yes, I was in that district. Our station was from Woolwich to Gravesend, or Northfleet, just above Gravesend.

2837. (*Dr. de Chaumont.*) How long were you in the Customs before that?—I could not say the exact time; but from 12 to 18 months I should think. I have not the particulars with me as to that, but it was over 12 months.

2838. And your knowledge of the Thames extends from 12 months before 1860?—I have been on the Thames from my boyhood.

2839. In what capacity?—In the first place I was a boy in a hatch-boat bringing fish to Billingsgate Market from the fishing smacks.

2840. Then you have known the Thames all your life?—Yes; I have known it for a great many years.

2841. (*Mr. Beaumont Morice.*) You knew it before the outfalls were made, and you have known it since?—Yes.

2842. Has there been any difference since the outfalls were made?—As regards the water, the water has been very bad since.

2843. In what way?—Such bad smells emanating from it.

2844. Do you smell those bad smells at any particular time?—Yes; I have noticed them most particularly when the water is still, in hot weather; and I have noticed the smell very bad in close foggy weather when the water has been still and quiet.

2845. Have you ever suffered from any sickness yourself?—I have not exactly been laid up, but I have felt very sick at times when I have been about the sterns of steamers, as I have been occasionally, sometimes sailing and sometimes rowing; and sometimes when the water was very still I have felt very sick.

2846. A sort of sickness you say?—Yes, I have never been laid up.

2847. I believe you live on the shore; you do not live on the boat, do you?—No, I live nearly a mile up inland.

2848. And I take it that it is when you are afloat that you experience this smell?—Yes.

2849. Have you ever seen any dead bodies taken out of the river?—Yes, I have seen several; not many since the "Princess Alice" disaster.

2850. You saw some then?—Yes.

2851. Will you tell the Commission what state they were in?—They were terribly swelled, and in a decomposed state after being a very short time in the water. I think there were as many as 24 lying at Erith in the engine house.

2852. (*Sir John Coode.*) How long was that after the disaster?—Some two or three days.

2853. You are sure it was not more?—I could not say positively to a day, but I know that it was very closely afterwards.

2854. (*Mr. Bidder.*) What was the date?—In September I think it was; the early part of September.

2855. (*Mr. Michael.*) I think it was the 2nd of September.

2856. (*Mr. Beaumont Morice.*) Was there any mud or anything else on them?—That I did not notice. I could not say.

2857. Have you noticed the mud about the ore-shore away down the river above Erith?—Yes.

2858. Do you know that part well?—Yes, well; I am up and down every day.

2859. Will you tell us what the mud is like up and down there?—It looks terribly black and dirty, and smells very badly at times, when there is a wash on the shore stirring it up.

2860. How far does that extend up the river from, say Erith?—It goes right up to the extreme of my district. My district goes to just up above the northern outfall, and it extends right up to the upper part of my district.

2861. (*Chairman.*) This black stuff extends up to the upper part of your district?—Yes.

2862. (*Mr. Beaumont Morice.*) From what part?—Say from Dartford Creek.

2863. Up past Erith, as far as the northern outfall?—Yes; but it is not so bad these last few months. These last two or three months the mud has gone away much off the shore.

2864. Why is that?—For the reason that it is drawn off the shore; it does not lie so thickly on the shore as it did.

2865. (*Chairman.*) Since when is that?—I should think it is three months since first I noticed it. It seems to be drawing more off the shore.

2866. (*Mr. Bidder.*) What part of the shore are you speaking of?—The river shore.

2867. (*Mr. Beaumont Morice.*) You say that it is black stuff; does it smell badly?—It does. A steamboat makes it smell badly when it is stirring it up.

2668. Has there been any alteration either in the quantity of it or in the smell of it during the last few years?—It has seemed to accumulate during these last few years until very recently, and now it seems to be drawing off the shore into the channel again, or going somewhere else.

2869. What part of the shore are you speaking of?—I might say from Erith very nearly up to Barking.

2870. That is to say about the limit of your district?—Yes.

2871. I take it that you know the south shore all up through Erith Bight?—Yes.

2872. Does the same thing hold there as well?—Yes, just the same; but still it is drawing off.

2873. Have you ever used the water for any purposes on board the boat?—We used to do so when I was in the Customs service frequently; in fact, at low water time we always used to dip our water; but we cannot do so now.

2874. Why cannot you use it now?—Because it is so bad.

2875. (*Mr. Bidder.*) The other day we thought we should shorten the proceedings on this matter by agreeing as to this.

2876. (*Mr. Beaumont Morice.*) I do not wish to take the witness through the fact that he did do it before and that he does not do it now; but I think I may ask the question why he does not do it now.

2877. (*Witness.*) It is so bad that we cannot use it for washing purposes or cooking, it smells so.

2878. (*Chairman.*) How do you mean that it is so bad?—It is so dirty and smells so.

2879. You do not use the water for washing or for drinking now, because it is so dirty?—Yes.

2880. (*Sir John Coode.*) What is the furthest point down the river at which you ever took the water for washing or drinking when you were in the habit of taking it for those purposes?—Very seldom below Erith on account of its being brackish.

2881. Have you taken it as far down as Erith?—Yes, many times.

2882. Have you found it quite fresh?—Yes, we have found it suitable for washing and cooking and all that sort of thing.

2883. (*Mr. Bidder.*) And for drinking?—No, I do not know that we have ever taken it there for drinking.

2884. (*Sir John Coode.*) How far down have you taken it for drinking?—We have taken it at Woolwich.

2885. Is that the farthest point down that you think it was ever taken for drinking purposes?—I cannot say that, but I think it is the furthest down that I ever had any for drinking purposes, in fact I think at the time when the smacks were there they used to dip their water at Barking Creek. I have heard the old fishermen talk about dipping there.

2886 (*Mr. Beaumont Morice.*) Why did you not dip lower down; say at Erith?—The water is brackish there.

2887. Have you ever noticed at what time the sewage is discharged from the outfalls?—Yes, I was directed to keep observation on the 1st of August 1880, I think, or to have observation kept, in order to ascertain whether it was running into the Thames on the ebb or flood.

2888. (*Chairman.*) Did you notice it?—Yes. On the 1st of August I posted a man at 9.30 a.m. on the bank at Crossness, and it was running freely into the Thames at that time and going up the river.

2889. Did you see it running into the Thames?—Yes, at 9.30 a.m.

2890. (*Sir John Coode.*) Did you notice the state of the tide at that time?—Yes, it was high water that day at 9.53 a.m. at London Bridge.

2891. (*Mr. Bidder.*) What time would it be high water at Barking?—There would be nearly half an hour's difference, so far as regards the flowing on the shore; but then the stream of tide would run up after that. I went on to the northern outfall at Barking, and at 10 o'clock, when I reached there, it was flowing into the Thames and going right up the river. On the 2nd of August it commenced running at 11.20 from the southern outfall.

2892. (*Chairman.*) Did you see it?—No, I cannot say that I did on that occasion. I posted a man there at the same time as the day previous, and it did not run so soon. The man reported to me when I took him into the boat, that it commenced running at 11.20. I did not see that myself; that was reported to me by the man that I placed there for the purpose. I went then myself to the northern outfall and it commenced running there at 11.15.

2893. (*Mr. Bidder.*) When was it high water on that day?—At 11.12 at London Bridge.

2894. That would be 10.40 at the outfall?—It would be later than that.

2895. (*Mr. Beaumont Morice.*) At what time would it be high water down at Barking?—There would be about half an hour's difference between Barking and London Bridge; 40 minutes to Erith, and 60 minutes to Gravesend.

2896. That is on shore, is it not?—Yes, that is the rise of the tide. The stream runs up after it is high water on the shore.

2897. You took it again on the 3rd, did you not?—Yes, I placed a man there at the same time at the southern outfall; and it commenced running there at 12.45, and at the northern outfall at 12.15; high-water at London Bridge being that day at 12.18.

2898. Now what was done on the 4th?—On the 4th there was only observation kept at the southern outfall, and the discharge commenced at 1.5. I have omitted putting the time of high water down on that day, but it would be somewhere about the time or a little before that, I should think, at London Bridge on that day.

2899. (*Sir John Coode.*) Is this all in 1880?—Yes; on the 1st, 2nd, 3rd, and 4th of August 1880.

2900. Have you any since that date?—No; that is the only time that I have been directed to keep any observation.

2901. (*Mr. Beaumont Morice.*) You watched it on four consecutive days?—Yes.

2902. Have you ever on any other occasion noticed at what time the sewage comes out, without being set to do it?—Yes, I have often seen it come out on the flood tide; but not recently.

2903. Of course if it comes out on the flood tide it goes up the river?—Yes; I have seen it a long way above the outfall.

2904. How far have you seen it above the outfall?—I have seen it above Woolwich and the water quite black.

2905. (*Sir John Coode.*) Have you traced this black water flowing all the way from Erith up to Woolwich?—Yes, right up the tideway.

2906. You have followed it up?—I have not exactly gone for that purpose; but I have seen it on my rounds. I have seen the black water going up with the sets of the tide.

2907. (*Mr. Beaumont Morice.*) Have you ever gone down the river to see how far it has gone down?—I do occasionally go down as far as Gravesend, but I never take much notice below what I call my own limits, that is to say below Dartford Creek.

2908. Have you ever noticed any lumps of stuff in the sewage?—I have seen quantities of round balls and the likes of that, lying about on the stones on the shore—greasy stuff, all up and down on either side of the river banks.

2909. In any particular part of the river?—I think in Half-way Reach. I have seen it more than anywhere, and by Cold Harbour Point I have seen a great deal of it.

2910. Is there much fat in the river at this time?—I have seen but very little about lately, but in the bays and in the slack water there is frequently lots of it and lots of slaughter-house refuse, such as sheeps lights, and all manner of filth of that description, floating about.

2911. I believe you have some men under you?—Yes.

2912. Have any of those men ever suffered from illness?—Yes; one man was suffering from diarrhœa. He was returned sick on the 6th of July and on the 6th, 7th, 8th, and 9th he was suffering from diarrhœa.

2913. (*Mr. Bidder.*) This is going too far, because it can only be mere hearsay, and what the cause of his diarrhœa was we cannot tell.

2914. (*Chairman.*) It may be the foundation of some valuable evidence, but at present it does not go very far.

2915. (*Mr. Bidder to the witness.*) This man reported to you that he was suffering from diarrhœa, and you gave him leave of absence?—Yes, he was reported by the doctor as "suffering from diarrhœa, "probably caused by bad smell on the river."

2916. Who was the doctor?—Dr. Jesset, the divisional doctor. I copied this from his entry in the sick book.

2917. (*Chairman.*) Was it one man?—Yes.

2918. What is his name?—Hogben.

2919. Was that this year?—Yes.

2920. (*Sir John Coode.*) How many men have you under you?—Four.

Examined by Mr. Lumley Smith.

2921. As I understand it you put the time of high water at London Bridge on one of these occasions at 11.12?—Yes.

2922. You say that high water at Barking is about half an hour earlier?—Yes.

2923. I understand you to say that you are speaking of the time when the water comes to its highest point adjoining the bank?—Yes.

2924. Does the stream continue to flow up past Barking after it has reached the highest point on the bank?—Yes; sometime afterwards, a quarter of an hour or 20 minutes, or sometimes half an hour.

2925. Then would sewage which was discharged at the time when the water has reached its highest point at the bank, still go up the river?—Yes.

Cross-examined by Mr. Michael.

2926. Are you perfectly clear about that? Is it not a fact that the stream runs down for half an hour before high water, by the side of the shore?—Yes, that is quite true.

2927. Therefore any sewage coming into the stream would be carried down, and not carried up?—It is carried down a certain distance and then it meets the up tide, up at the point, at Barking.

*G. Roberts.*
21 Nov. 1882.

2928. Would you kindly tell me who gave you the direction in 1880 to make these observations?—My superintendent came down and left a memorandum in the book; I suppose it would be the Commissioners order. I do not know who else it would come from. I was called upon to report upon the 5th.

2929. (*Chairman.*) What is the superintendent's name?—Superintendent Alston. He made an order in my book for me to keep observation.

2930. (*Mr. Michael.*) Does the paper which you have there contain the whole of the memoranda which you made in accordance with that order?—No; that is simply just to refresh my own memory.

2931. Where are all the rest of the memoranda?—What memoranda do you mean?

2932. You have taken this out from some memoranda, I suppose?—Yes.

2933. Where are the other memoranda?—On board of my vessel.

2934. How is it that you took this out and left the remainder behind?—I simply wanted it to refresh my memory.

2935. Did you consider this the most important portion of all the observations that you made?—I thought so.

2936. How long were you about the matter altogether?—Four days. Superintendent Alston came down on the 31st of July, and he directed me to keep observation or to have observation kept, for a few days, and I was to send in a report upon the 5th. Consequently on the morning of the 5th I sent in my report, and that is what I sent in.

2937. But I cannot make that agree with what you have given us, because you have one memorandum here, "Bad smell on the river on the 2nd and 30th of July"?—That is another thing.

2938. How long did all these observations extend from which you have extracted "Bad smell on the "river 2nd and 30th of July"?—That was this year. We had two very still hot days; I suppose they were two of the hottest days we had, and the river on those two occasions smelt very badly; and I made a note of that in case I should be asked the question.

2939. (*Sir John Coode.*) Is that a copy of what you sent to the superintendent, or did you send him a full copy of the notes that you had in your book?—I sent him a full copy.

2940. (*Chairman.*) You made a report in writing, I suppose, to the superintendent?—Yes.

2941. Is not that writing here?—No.

2942. You could bring it, I suppose, or the superintendent could bring it?—My books could be produced.

2943. You say that you made the report in writing; did you enter it in your book?—Yes.

2944. It was not addressed in the form of a letter to the superintendent; it was written in your own book?—It was written in the book and then a copy was sent to the superintendent.

2945. The superintendent ordered you to make a report?—Yes.

2946. And you made a report?—Yes.

2947. And that report was in writing?—Yes.

2948. And it was addressed to the superintendent?—Yes.

2949. So that the superintendent would probably have it then?—I should think he would forward it on to the Commissioners; I do not know.

2950. (*Mr. Michael.*) Did the report only extend over these four days, the 1st, 2nd, 3rd, and 4th of August?—That is all.

2951. Then anything that appears on this bit of paper beyond that is something that you put down yourself?—That is it.

2952. And you did not take any other observations, save on those four days, except what you have casually made a note of here?—That is it.

2953. What, for the last four years, has been the extent of the beat that you have specially to attend to?—Between Dartford Creek and Beckton; that is just above the northern outfall.

2954. Then you have nothing to do with Erith?—Yes.

2955. Are you on the river all day long?—Not all day.

2956. How many hours?—Sometimes I am out on a morning, sometimes in the evening, sometimes in the middle of the day, and sometimes at night.

2957. Have you the four men with you at the same time; do they live on the river?—Yes, three out of four live on board the vessel. I have one married man who lives on shore.

2958. Where is that vessel moored?—Right off Erith pier, or nearly opposite the pier.

2959. What is the name of the married man?—Mastin.

2960. How many other men belonging to the police live on board the vessel?—Three single men.

2961. Are those the only three river police living on the river in that section?—Yes.

2962. Then do any of the other police live on the river in boats in any of the other sections?—No, not below the Blackwall station.

2963. Then from Blackwall down to Dartford there is only one station for the river police, and they live on the river, is that so?—The Blackwall station extends down to Barking, and I go up and meet them at Barking Creek.

2964. Are there any other stations of the river police?—Not below mine, my station is the lowest.

2965. With regard to this bad smell on the 2nd and 30th of July, that was on the river itself?—Yes.

2966. What kind of smell was it?—A nasty, filthy, smell like rotten soap suds. I could hardly describe the smell.

2967. Where did you smell it?—In Barking Creek I smelt it very badly, and so I did in Half-way Reach.

2968. That was in the river itself, of course?—Yes.

2969. Have you ever smelt that smell on the land anywhere?—No, I never noticed the smell on the land.

2970. How many years have you been on the river?—Very nearly 40 years.

2971. On this portion of the river?—This last time I have been here, now, about 4½ years.

2972. When did you first notice that the deposit of mud was diminishing from Erith and up along the banks of the river?—I should think it is two to three months ago; I could not say exactly how long.

2973. Is the diminution large?—Yes, it seems to have gone away considerably.

2974. At Erith itself?—Yes, at Erith and at other places up along the river shore.

2975. What is the colour of the mud there?—It is a sort of bluish brown.

2976. Is it different in colour from the mud which you observe on the banks of the river in other portions?—It is very different from what it is further down.

2977. How far down?—Say below Greenhithe; from Greenhithe to Gravesend, or below Gravesend.

2978. How far up does this mud of this bluish brown colour extend?—Up into Gallion's Reach, whether or no.

2979. Do you know Barking Creek?—Yes.

2980. What is the colour of the mud there?—It is very seldom that I go up the creek; I pass the creek's mouth.

2981. What is the colour of the mud at the mouth of the creek?—It is about the same. It is a darker colour there.

2982. A bluish brown?—Yes, a darker colour.

2983. Throughout the extent of your beat does it remain of the same colour all the way up?—I do not see much difference in it.

2984. Then may I take it that from Blackwall to Dartford this mud extends the whole way?—From Beckton just about the same.

2985. Is it the same on both sides of the river?—I do not think there is much difference.

2986. Where is it that the mud has been extending during the last three or four months?—It is drawing off into the bed of the river I should imagine.

2987. That is imagination on your part; you do not know that it is in the bed of the river?—No; the only reason I go by is that when I am rowing my boat up along the shore at low water time we can feel the mud a long way off, 20 or 30 yards.

2988. Do you mean that you can perceive the smell of it?—No, we can feel it with the oars.

2989. Do you see any dredging operations going on in the river?—Yes, there are some in Long Reach.

2990. What is the character of the material that is brought up by those dredging operations?—Principally ballast and gravel, I think. That is some distance down below Erith, a mile and a half or two miles.

2991. You have had four men under your orders for the last four years?—Yes.

2992. How many days have those four men been off duty during the whole of that time?—I could not tell you unless I had my sick book. They are something like myself; they are pretty strong, and they are not very sickly.

2993. (*Mr. Bidder.*) We may take you as a fair sample?—Yes, I think you might.

Re-examined by Mr. Beaumont Morice.

2994. You say the oars touch the mud coming up; that is some distance from the shore, is it not?—Yes; I noticed that on Sunday last particularly, at low water.

2995. So that you find it becoming shallower farther from the shore than it used to be?—Yes; it seems to me as if the mud was drawing off from the shore, from inside low-water mark to the outside of it.

2996. Do you think that the amount of rain and fresh water coming down the river has anything to do with that?—I have noticed that when the water has been very bad, if we have had a shower of rain or a breeze of wind, it seemed to sweeten the water somewhat.

2997. With regard to the gravel that you said was taken up at Long Reach, that is a straight reach, is it not?—Yes.

2998. You often have freshets down the river, do you not, at this time of the year?—Yes, we have had the fresh water extending down that far.

2999. Do you notice any difference either in the water itself or in the banks, after freshets?—I cannot say that I have taken that particular notice; but we can always tell by the colour of the water when the freshets are down.

The witness withdrew.

Mr. Edward Arundel Carttar called in; examined by Mr. Beaumont Morice.



3000. I believe you are one of the coroners for the county of Kent?—I am.

3001. Will you tell the Commission the extent of your district?—My district extends from Rotherhithe to Gravesend, mid-stream.

3002. Where do you reside?—At Greenwich. My district also extends to the north side of mid-stream, in the parish of Woolwich.

3003. That part of the parish of Woolwich which was in the county of Essex?—Yes.

3004. I think you have been coroner for about two years?—Two-and-a-half years.

3005. And your father was, I think, coroner for something like 50 years?—He was.

3006. And I believe during part of the time you assisted him in his duties, did you not?—No, I did not.

3007. (*Mr. Bidder.*) Is the office of coroner hereditary in Kent, then?—Not quite.

3008. (*Mr. Beaumont Morice.*) During the time that you have been coroner how many inquests have you held?—Over 800.

3009. How many of those have been on bodies taken from the river?—I made a calculation last night, and on reckoning it up I found that about 98 were out of the river Thames; about 156 altogether out of water.

3010. (*Sir John Coode.*) Over what other water does your district extend besides the Thames?—The river Ravensbourne and the river Darent; and then I have the Grand Surrey Canal, and ponds and ditches, wells, baths, butts, pails, docks, and so forth. I have jurisdiction in 11 parishes that abut on the river, and I have had 98 inquests on bodies taken from the Thames.

3011. I believe that in last year, 1881, you had 32 inquests on bodies recovered from the river Thames?—I had.

3012. Can you tell us, without any trouble, what parts of the river they were taken from, or where you held the inquests?—Yes. I am supposed to hold them in the parishes where they are found. There were two in the parish of St. Paul, Deptford, one in St. Nicholas, Deptford, 14 in Greenwich, four in Charlton, nine in Woolwich, and two in Erith; that is 32 altogether.

3013. What has been the condition of those bodies that have been taken out of the river?—There is a marked contrast between them and those that I have had before me which have been taken out of other water—fresh water, out of the river Ravensbourne, and the river Darent, and out of canals and ponds, and ditches, and wells.

3014. What is the contrast?—In the one case, that is to say, in the case of bodies taken from the Thames, they are very much discoloured and disfigured, by the gas, I presume. They turn, at various stages, from pink to white, and green, and blue to black, and the decomposition is very rapid in summer in the case of those that come from the Thames, particularly below Charlton. Two or three days is sufficient.

3015. Is there any deposit of any kind upon the bodies?—Very often, of mud and filth, and there are complaints about it.

3016. (*Sir John Coode.*) That would be the case in every muddy river, would it not?—It would.

3017. The question is as to the kind of deposit?—In some cases we have sand in the pockets, and so on.

3018. Whatever the prevailing matter may be on the shore of the river is found accumulated about the clothes and the bodies. The kind of matter is under consideration in this case?—It is very offensive to the smell; that is all I can say. I am not a chemist.

3019. And more so with these bodies recovered from the Thames than with those recovered from the other waters with which you have to deal?—Very much more so.

3020. (*Mr. Beaumont Morice.*) Is there or is there not a marked difference between what you get from the Thames and what you get from any of these other rivers?—There is a very marked difference.

3021. (*Chairman.*) In what condition do you find the bodies that are taken from the Surrey Canal and from the docks?—They are comparatively clean.

3022. You do not find any mud or any offensive matter about them?—A little, but a very little, in the Grand Surrey Canal.

3023. (*Dr. Stevenson.*) Can you speak as to mud being found upon the bodies from the docks?—Yes; I have the Albert Dock in my district at North Woolwich.

3024. Do you find mud on bodies that are taken from the docks?—Slightly.

3025. Is that offensive?—I have not noticed it.

3026. (*Mr. Beaumont Morice.*) Will you tell us in what particular parts of the river you find that the

*Mr. E. A. Carttar.*

21 Nov. 1882.

bodies come out worst?—Further down my district, as a rule, I think.

3027. What do you call further down?—Below Charlton down to Erith.

3028. (*Sir John Coode.*) Will you kindly tell us between what points?—Between Charlton and Gravesend. There is a contrast between that and up the river to Rotherhithe.

3029 (*Chairman.*) From Charlton to Erith is the worst?—Yes, decidedly so.

3030. (*Mr. Beaumont Morice.*) How long have you known the river itself altogether?—About 26 years, I should reckon, as long as I can remember.

3031. Can you tell us (not from your official knowledge, of course) what in the early part of that time was the state of the river?—It has greatly improved of recent years.

3032. In what part of the river?—At Greenwich particularly, and higher up.

3033. With regard to the river below Greenwich, what do you say?—It has become worse, I think.

3034. I think you held an inquest as lately as the 24th of July, did you not, in the neighbourhood of Erith?—Yes, I think it was on the 24th of July; on a Monday, I think it was.

3035. What was it?—It was the case of a man who was accidentally drowned off Tripcock Point through the upsetting of a pleasure boat on the Sunday week previous. On the 16th, I think it was. The body was recovered five days afterwards in Erith Wash, and it was in a very bad state indeed, disfigured and swollen, and covered with filth and slime and mud. It was an exceptionally bad case, and it was strongly commented upon by the jurymen, though they are used to bad cases down there.

3036. Did you have anything to do with or did you see any of the bodies that were recovered from the "Princess Alice"?—No, I did not.

Cross-examined by Mr. Bidder.

3037. About this case which you refer to, in which an inquest was held by you on the 24th of July; when did you see the body?—I saw it in the mortuary of the parish church at Erith.

3038. When you held the inquest?—Yes.

3039. You would, of course, view the body with the jury?—I did so.

3040. And the man having been drowned on the 16th he had been eight days dead when you saw him?—He had. He had been five days in the water and three days out of it.

3041. And that in the latter part of July?—It was.

3042. I suppose you do not happen to know what the temperature of the river is in the month of July?—No, I do not. It was not warm at that time this year, I think.

3043. You were good enough to say something about the remarks of the jury. I have before me a newspaper report of that inquest, and I find a remark of the coroner's, but no remarks on the part of the jury. Was there anything in the verdict of the jury with reference to the condition of the river?—No, there was not.

3044. Do you know anything of a paper called the "Bexley Observer"?—There is such a periodical, I think.

3045. Did you see the newspaper report of that inquest?—I did not.

3046. Are the newspaper reporters wrong if they represent the only remarks as to the condition of the river as proceeding from yourself?—Yes, they must be wrong. I do not remember if there was a reporter there, even.

3047. It is evident that there was a reporter?—I find that reports go into the papers that are not reported by the officials connected with the press.

3048. Did any one, as a witness, before that inquest make any complaint about the condition of the river?—Yes, many times.

3049. What is the name of the witness?—Arthur Collins.

3050. (*Chairman.*) Do you happen to have your own notes of that inquest with you?—I have not.

3051. (*Mr. Bidder.*) In 1881 you had 32 cases out of the river, I think you said?—I had.

3052. And other cases out of other waters; and you tell the Commission that there was a marked contrast between the condition of the bodies taken out of the river and those taken out of ponds and rain butts and smaller streams?—I did say so.

3053. Is it a fact that as a rule the bodies are very much more quickly recovered in the case of people who fall into rain-butts and small ponds, and that the bodies of people who are drowned in the river are generally two or three or more days before they are got out?—I have taken that into consideration in giving my answers.

3054. Will you be good enough to answer the question. Is it not the fact that the bodies of people who are drowned in the river are usually much longer in the water than those of people who fall into ponds or into rain-butts?—Usually; but not always.

3055. For instance, in the case of this inquest that you have spoken of, this man had been five days in the water?—Yes.

3056. Can you tell me the number of days that the 32 persons that you held inquests on in the year 1881 had been in the water, or any of them?—No, I cannot say; in the case of some as much as a month, I should think.

3057. You were good enough to say that the condition of the river at Greenwich and above is better than it used to be?—In my opinion; speaking from my own observation, it is.

3058. And below Greenwich, do I understand you to say that it is worse?—Yes.

3059. Did you know anything of the condition of the river before the outfalls were open?—I have been up and down the river.

3060. It is nearly 18 or 20 years ago?—I was young at the time.

3061. When you say it is worse, you are comparing it rather with the condition since the outfalls were opened, and not with the condition before the outfalls were opened?—I knew it before the outfalls were opened.

3062. Are you prepared to say that it is worse than it was before the outfalls were opened?—As far as my recollection goes.

3063. May I ask what age you were before the outfalls were opened in 1864?—Sixteen. I am 35 now.

3064. Then you were 17?—About that.

3065. Probably a considerable portion of your me was then occupied in education in some seminary or seat of learning?—Yes.

Re-examined by Mr. Beaumont Morice.

3066. And I suppose that your time was also, some part of it occupied on the water?—Occasionally.

3067. Have you noticed during the past few years any perceptible difference?—I was absent for 10 years, so that I cannot speak until recently.

3068. You have been asked about this report; I see that you are reported to have said ——

3069. (*Mr. Bidder.*) He was cross-examined as to whether the jury had said anything; not as to what he had said.

3070. (*Mr. Beaumont Morice to the witness.*) You were asked whether you were not the only one who made any remark. I call your attention to what you are reported to have said ——

*Mr. E. A. Carttar.*
21 Nov. 1882.

3071. (*Chairman.*) You may ask him what was the remark that he made.

3072. (*Mr. Beaumont Morice to the witness.*) Did you make any remark, and if so, what did you say?—I believe I did make some remark, but I cannot remember now exactly the purport of it, except that it was as to the offensive state of the river.

3073. (*Mr. Lumley Smith.*) The attention of the witness has been called to this paper by my learned friend, and he has been using it for his own purpose.

3074. (*Chairman.*) But the paper has not been put in in any way, and would not be evidence. In fact I have been watching Mr. Bidder to see what use he was going to make of it. He merely asked whether any other person except the coroner had made a remark, and the coroner said the jury did. I think you are entitled to ask the coroner what remark he made.

3075. (*Mr. Beaumont Morice.*) He has been asked by my learned friend whether or not he was the only person that made a remark; and that being so, I submit that I am entitled to ask him now whether he did not make such a remark.

3076. (*Chairman.*) You are going to read to him the passage, and ask him whether that is the remark he made?

3077. (*Mr. Beaumont Morice to the witness.*) Did you make any remark bearing upon the state of the Thames?—I believe I did.

3078. (*Mr. Bidder.*) The observation of the coroner then would be the expression of his opinion, and he can make it now if he has any opinions upon the subject.

3079. (*Chairman.*) He may make it now; but I do not know that Mr. Morice is not entitled to ask him whether he did not make it then also.

3080. (*Mr. Beaumont Morice.*) I will try and meet my learned friend if I possibly can. (*To the witness.*) Have you any opinion with regard to the poisonous state of the river Thames now?—I do not think it is very satisfactory.

3081. (*Chairman.*) You have said that above Greenwich it is satisfactory?—There is a great improvement.

3082. But below Greenwich it is worse; that is your general impression?—Yes.

The witness withdrew.

GEORGE MASTIN called in; examined by Mr. BEAUMONT MORICE.

*G. Mastin.*
21 Nov. 1882.

3083. You are in the Thames Police, and you are stationed on board the police-boat at Erith, are you not?—Yes.

3084. How long have you been there?—Over 3½ years now.

3085. Before that what were you doing?—I was on the Wapping station.

3086. How long have you been on the Thames?—About 25 or 26 years altogether, as near as I can guess.

3087. Do you remember the state of the river before the outfalls were opened?—Yes.

3088. Will you tell us generally what it was?—It was much better than it is at the present time.

3089. In what way?—It was much purer, according to my idea, and there was not the foulness in the water that there is now. The water did not smell so bad.

3090. (*Colonel Ewart.*) What part of the river are you speaking of?—I should say between Crossness and Gravesend.

3091. (*Mr. Beaumont Morice.*) Do you go up and down the river much?—Yes, daily.

3092. And you know the state of the foreshore all up and down?—Yes, between Erith and Beckton.

3093. Can you tell us what sort of mud there is on the banks?—The kind of mud that has a yellowish, slimy look about it; not a sandy soil as it used to be in former years.

3094. (*Mr. Bidder.*) May I submit to my learned friend two things: one, that the real nature of the mud is only to be got at by people who have examined it analytically; another, that its outward appearance can be seen by the Commission themselves?

3095. (*Chairman.*) We have long been sensible of that. This man can only tell us that there is a deposit of a certain colour and texture, and that it is slimy and smells badly, of all which we can judge for ourselves.

3096. (*Mr. Beaumont Morice.*) But the fact of this witness being able to state that, and the fact of my being able to prove it, to the extent to which I am prepared to show it, is of course my very case, not only that it is mud, but that it is mud of a peculiar description, and that is what my learned friend will not admit.

3097. (*Chairman.*) The only peculiarity in the description that he can give is a slimy, bad-smelling mud.

3098. (*Mr. Beaumont Morice.*) And further, that it came there after the outfalls were made; so that these points are of the first importance. (*To the witness.*) Can you tell us what sort of smell it is?—It is a very offensive smell.

3099. Have you ever suffered any sickness or illness from it?—Yes, at times I have had to go out of the boat on account of the smell of the water. That was more in hot weather than in windy weather. I felt very sick; and in fact I have had to vomit once or twice on account of feeling so sick; and that has been when the weather has been very hot and calm.

3100. Are you accustomed to use the water of the river on the boat?—Only for washing the decks of the vessel down with.

3101. Why cannot you use it for other purposes?—On account of the foulness of the water.

3102. (*Chairman.*) The water is dirty, is it?—Very dirty.

3103. And that is the reason why you cannot use it?—That is the reason. At times when we have been cleaning the vessel down, we have had to skim the bucket along the surface of the water on purpose to get the grease and slime off, to get at the water underneath to wash the vessel down with.

3104. (*Mr. Beaumont Morice.*) Why is that?—I should say it is on account of the sewage, or the contents that come from the different sewers.

3105. On the top of the water?—On the surface of the water.

3106. Have you had anything to do with dead bodies that come out of the river?—Occasionally.

3107. In what state have they been?—In a very decomposed state.

3108. When have you had to do with them?—I had one recently that had been in the water four days, and he was lying in the mortuary, and he turned very decomposed.

3109. (*Chairman.*) When was that?—I think he was drowned on the 24th of July, and picked up on the 28th.

3110. (*Mr. Bidder.*) Is that the case in which the inquest was held?—The inquest was held on the body at Erith.

3111. (*Sir John Coode.*) It cannot be the same, because this man was drowned on the 24th, and recovered on the 28th; and in the other case the man was drowned on the 16th, and the inquest was held on the 24th.

3112. (*Mr. Beaumont Morice to the witness.*)—Have you ever noticed at what time the sewage comes out of the outfall?—I have not taken any particular time, because it is such a daily occurrence.

3113. Have you ever noticed when it comes out?—As a rule it has been high water time, and perhaps a trifle before high water, which has caused it to come up the river; that is from the southern outfall; but I cannot state the time.

*G. Mastin.*
21 Nov. 1882

3114. Why do you say that you have noticed that it is sewage coming up?—Because in going up and down the river I always go up and down that shore ; and sometimes when I have been rowing down on the flood tide just below Half-way House, which lies above the sewage, I have met the sewage coming up with the flood tide.

3115. How can you tell that you met the sewage? —By the colour of the water.

3116. What colour is it?—Very black.

3117. Is there any smell from it?—A very offensive smell.

3118. Do you know anything about the Dutch eel-scoots that used to lie in the river?—As a lad I recollect their lying at Erith, but not to form any proper opinion of them. I have seen them lying there.

3119. Do you know how long ago they have dropped coming here?—I could not give a definite date, but it is some years ago; as far as I can guess some 17 or 18 or 19 years ago ; but I should not like to say for a year or two.

3120. Did you see any of the bodies that were drowned in the "Princess Alice"?—Yes.

3121. Where were you then?—In the police-boat at Barking, dragging for them on the morning after the accident.

3122. How many did you get?—I assisted in getting 31 bodies on board the steamboat,—the first bodies that were conveyed to Woolwich.

3123. How long was that after the accident?—But a very few hours.

3124. What state were they in?—They had a very reddish appearance, and they were discoloured.

3125. Did you notice anything else about them excepting that they were discoloured?—I noticed froth coming from several of their mouths.

Cross-examined by Mr. Bidder.

3126. You are not a medical man, I suppose?—No.

3127. You do not know what the symptoms of drowning are?—No.

3128. You said that these 31 bodies were seen by you a few hours after the accident?—Yes.

3129. How many hours after ; four to six hours? —It might have been more. It was under the 24 hours.

3130. You have spoken about the condition of the river. How old are you?—39 last April.

3131. Where were you engaged before you were on the Erith boat?—I was a police officer at Wapping, on the Wapping station.

3132. Which are the bounds of the Wapping station?—As a rule there are beats laid out for the officers to patrol with their boats.

3133. What was the beat that you had to patrol on the Wapping station?—Sometimes it was from Wapping to London Bridge, and sometimes from Wapping to Blackwall.

3134. In point of fact, the station is from Blackwall to London Bridge, and sometimes you have the upper beat, and sometimes the lower beat; is that so?—Just so.

3135. How long were you there?—I think I was on that station about 18 months.

3136. Where were you before that?—On the Gravesend station.

3137. How long were you there?—Nearly four years.

3138. Where were you before that?—On the Blackwall station.

3139. How long were you there?—I should think I was there for about four years.

3140. Where were you before that?—Serving my time on the river in the steamboats.

3141. What sort of boats?—Saloon boats ; the "Alexandra" and the "Palmerston."

3142. Running where?—From London Bridge to Gravesend, Southend, and Sheerness.

3143. (*Sir John Coode.*) How long were you in that service?—Several years.

3144. In what capacity were you working on those steamboats?—As deck hand.

3145. (*Mr. Bidder.*) Now, I understand that you go up as far as Beckton, and down to Erith?—We have no limited distance. It rests with the inspector.

3146. Do you ever get up as far as Beckton?—Daily.

3147. Do you know the Beckton Gasworks?—Yes.

3148. Do you know the sewer there?—No, I do not exactly.

3149. Have you never seen anything of the sewer there?—I have seen the northern outfall at Beckton.

3150. Are you under the impression that when I speak of a sewer at Beckton I am alluding to the sewage at Barking?—I have not seen any sewer at Beckton.

3151. If you tell me that you do not understand the question, I will not ask you any further question. My question is, have you ever seen a sewer at Beckton. Do you understand that question?—Yes.

3152. Then answer it?—You do not refer to the pumping station?

3153. No, I am speaking about Beckton. Do you know Beckton?—Yes.

3154. Do you know the northern outfall?—Yes.

3155. Do you know that the northern outfall is not at Beckton?—I have not been on the ground to know the parish.

3156. (*Chairman.*) You know Beckton, do you not?—Yes, but not the parish of Beckton.

3157. There are some gasworks there, are there not? —Yes.

3158. Is there a sewer there?—I have not noticed one.

3159. You do not know?—No, I do not.

3160. (*Mr. Bidder.*) Have you ever seen anything coming into the river at Beckton?—From the northern outfall?

3161. Is the northern outfall at Beckton?—No.

3162. (*Chairman.*) Have you seen anything flowing into the river at Beckton?—I have not; nothing has come under my notice.

3163. No drain, and no sewer of any sort or kind? —I should not like to say that there is not but I have not noticed one.

3164. (*Mr. Bidder.*) You have never heard of anything coming in there from the gasworks?—No.

3165. When was it that you had to get out of your boat because you felt ill?—I should say that it would be from July to August in the summer before last

3166. When did it last happen?—I did not put it down at the time; but it was about the month of August 1881.

3167. Whereabouts were you?—At Erith.

3168. When you went out of your boat where did go to?—I went ashore.

3169. Where did you go to when you got ashore?— I went to get some refreshment, because I felt so sick and faint.

3170. Did you go to a public-house?—Yes, I could not get any refreshment anywhere else.

3171. Did you stop there long?—No.

3172. When you got to the public-house, what did you have?—I cannot say now, because it is such a long time ago to recollect what I had. I should not like to say.

3173. Are you allowed to land and go to a public-house whenever you please?—No.

3174. You must ask sick-leave?—I was in a boat by myself.

3175. Then you could do as you pleased?—I had no one to ask, if I was in a boat by myself.

3176. Were you in the boat for pleasure, or on business?—I was not on regular duty at the time ; I

*G. Mastin.*

21 Nov. 1882.

was working on one of the boats, cleaning it out; it was in my own time.

3177. Your time was your own?—My time was my own.

3178. Having cleaned the boat out, you landed and went to the public-house?—Before that; I could not stop to finish the boat.

3179. Did you stop long at the public-house?—No, I did not.

3180. Did you go on duty again that day?—No, I did not.

Re-examined by Mr. Beaumont Morice.

3181. Did you leave the boat because you wanted to drink, or because you felt faint?—Because I felt faint.

3182. You felt sick, and you wanted something for it?—Just so.

3183. You have been asked about this sewer at Beckton. Do you know Beckton at all well?—Only from the water side.

3184. You do not know whether there is any sewer there at all?—Not to my knowledge.

3185. But I understand you to say that you have been all your life upon the river?—Yes, I have; ever since I was a lad.

3186. And therefore you have no doubt as to the difference between the state of the river now and what it used to be?—No; there is a great difference.

3187. Can you tell me the distance of Beckton Pier from the northern outfall?—I should say it is from 300 to 400 yards.

3188. (*Mr. Bidder, through the Commission.*) Where were you cleaning that boat?—At the Erith Pier,—inside the Erith Pier.

3189. (*Chairman.*) With respect to these 31 bodies that you got up a few hours after the wreck of the "Princess Alice," did you observe in what condition the clothing upon any of those bodies was?—No, I did not take that notice.

The witness withdrew.

3190. (*Chairman.*) Have you any more witnesses of this character?

3191. (*Mr. Beaumont Morice.*) I have one more, sir.

3192. (*Chairman.*) It is time that we came to something that touches more than the fringe of the case.

Sergeant Charles Gilham called in; examined by Mr. Beaumont Morice.

*Sergeant C. Gilham.*

3193. You are sergeant of the R Division of the Metropolitan Police, stationed at Woolwich?—Yes.

3194. And you have been in the police force for about 10 years?—Yes.

3195. And for, I think, five years you were coroner's officer?—Yes, rather better than that. Before that I was in the navy.

3196. During the time that you have been stationed at Woolwich have you noticed the state of the river?—Yes.

3197. Will you tell the Commission what it is?—Very bad indeed; it is very thick and dirty, too.

3198. (*Chairman.*) Is there any smell?—Yes, very bad in hot weather, especially when they open the penstock from North Woolwich.

3199. (*Mr. Beaumont Morice.*) During the time that you were coroner's officer did you have to do with the "Princess Alice" bodies?—Yes.

3200. In what state were they?—The colour of their clothing was completely changed altogether.

3201. (*Chairman.*) You saw that yourself?—Yes. They were covered with slime and mud. After the bodies were stripped large black blisters came upon the skin, varying in size, some larger than the palm of your hand, and they smelt very badly indeed.

3202. (*Sir John Coode.*) How long after the wreck had these bodies been recovered?—Some the next day.

3203. Is it of those that were recovered the next day that you are now speaking?—Yes, almost all of them. Those which had been immersed longer were worse.

3204. Were the great part of them recovered within 24 hours?—A great many of them.

3205. (*Dr. Stevenson.*) Did you find the blisters in 24 hours, or later?—In 24 hours, that is to say, if the bodies came up anywhere near the Gallion.

3206. (*Mr. Beaumont Morice.*) Was there any stuff on the bodies and clothes?—Yes, a kind of slime, which was very bad. I believe it was sewage.

3207. Was there any smell to it?—It smelt very badly; in fact we had to boil the clothing before we could get it identified in many cases.

3208. (*Sir John Coode.*) Was the object of boiling it to get rid of the accumulation of matter that had taken place in the clothes, or was it to purify the smell?—To purify them; you could not recognise the bodies in most cases. The bodies in many cases were recognised by the clothing, and we had to wash the clothing really because it was in such a filthy state.

3209. Did you take off the clothing and boil it?—Yes, we had one of those steam coppers.

3210. (*Mr. Michael.*) They were put into one of the apparatus that is employed for the purpose of disinfecting clothing, was not that so?—Yes, I believe it was. It was done to identify the clothing.

3211. (*Sir John Coode.*) Did you strip the clothing from the bodies?—Yes.

3212. And then you boiled the clothing?—Yes.

3213. But it could not be identified before it had gone through this boiling process?—No.

3214. (*Chairman.*) What prevented the identification before the boiling process?—The clothes were in such a filthy state, and smelt so badly, that you could not show them to anyone.

3215. (*Mr. Beaumont Morice.*) The clothes were then literally boiled to take the filth off them?—Yes, and dried.

3216. (*Dr. Stevenson.*) Could the clothing have been recognised or not?—Yes, I dare say it could have been recognised. It was not in a fit state.

3217. (*Chairman.*) I understand what you say is this, that they were obliged to boil the clothes because the whole thing was so offensive that they could not show the clothes to the people who came to see them?—That is my meaning.

3218. (*Sir John Coode.*) But in addition to that, I think you said they were boiled for the purpose of identification?—Yes, because it was easier to identify them that way than it would be the other.

3219. Then it was for both purposes?—Yes.

3220. Both for the purpose of purification and for the purpose of identification?—Yes; a great many bodies were entirely identified by the clothing.

3221. (*Mr. Beaumont Morice.*) Subsequently to that, what has been the condition of the bodies that have been taken from that part of the river?—They have been in a very bad state after they have been in the water for a very few hours. After they are stripped and washed they turn quite black in no time.

3222. There is a causeway at Woolwich, is there not?—Yes.

3223. On the ebb-tide what state is that causeway in?—It has to be washed down as the tide recedes. It is very slimy and slippery, and covered with filth—generally black mud.

3224. Is there any smell?—In hot weather particularly.

3225. Have you had to do with any bodies that were taken from any other water except the river?—A good many.

3226. What other water?—From a pond upon the common; from the reservoir.

*Sergeant C. Gilham.*

21 Nov. 1882.

3227. Are they different from those which you take out of the Thames?—Yes; they keep a great deal better. In fact, they turn green before they turn black. It is very seldom that the blisters come on them; in fact, not nearly so quickly. Those blisters that I speak of are of an immense size, some of them containing fluid as black as ink.

3228. (*Sir John Coode.*) Do you mean blisters, or black spots?—Blisters raising the skin right up.

Cross-examined by Mr. Michael.

3229. Do you mean that without the intervention of any other decomposition, the bodies out of the Thames turn black?—Yes.

3230. Like your coat?—My coat is blue; but these are quite black, as black as ink, so that the blisters come out black first.

3231. How long has a body been in the Thames before that condition of things occurs?—I have had them 10, 12, 14, and 20 hours. The longer they are in the quicker they turn black after.

3232. How long after?—Say, for instance, you take a body that has been in the water some 24 hours; before that body is stripped and washed, if it comes from the lower part of the Gallion, particularly off Beckton Gasworks, it will turn bad and blister in less than seven or eight hours after it has been washed.

3233. And it turns perfectly black?—Yes.

3234. You have mentioned the gasworks; do you know the Beckton Gasworks?—Yes.

3235. How do they get rid of all the refuse matter from the Beckton Gasworks?—Well, I believe some of it is sent into the Thames.

3236. How near to the Beckton Gasworks have these bodies been taken out that you spoke of?—I have had bodies right from the Beckton Gasworks close to the pier.

3237. Did they turn black?—Yes, the same thing applied to them as did to the other bodies in other parts of Gallion's Reach.

3238. Are you able to localise the parts of the river from which the bodies turn black when taken out in this way?—I should say particularly from Charlton Pier downwards to the other side of Tripcock Point. I do not know much about the river any further down.

3239. That is from Charlton Pier down to Half-way Reach?—Yes; that would embrace Woolwich Reach and the Gallions. I have not had much to do with the bodies in the river anywhere else.

3240. Were you officer to Mr. Carttar who was here?—I have been.

3241. For how long; for the two and a half years that he has been in office?—I was officer for his father long before that.

3242. Then all the bodies recovered from the river come under your cognizance?—Yes, from that portion of the river, that is to say, below Greenwich, from Greenwich to the lower part of the Gallions, Tripcock Point.

3243. How far does Mr. Carttar's district extend altogether?—It extends right away down the river.

3244. Do any bodies recovered between Rotherhite and Gravesend come within your jurisdiction?—From the lower part of Greenwich to Tripcock Point.

3245. Are you able to say that there is a difference between bodies recovered off Greenwich and bodies recovered off the Beckton Gasworks?—Yes, and there is a considerable difference in those recovered off Charlton.

3246. And those are the ones that turn black, as you have described?—No, they turn more green; in fact they keep better if they come up off Charlton.

3247. Then it is only in a very limited portion of the river that this blackness occurs?—The portion of the river that I am speaking of.

3248. Putting Beckton as the westerly point, how far does it go down to the east?—It comes right up, I should think, to the Woolwich Dockyard.

3249. That is going the other way, to the west?—I do not know of anything below Tripcock Point.

3250. You said something about the discharge from the penstocks at North Woolwich; is the river very bad when those penstocks are opened?—Yes, the water is discoloured for some considerable distance, and in the warm weather it smells very badly.

3251. How often does that occur?—That I could not exactly say; I believe once in every 24 hours; but of that I am not positive.

3252. How often have you seen it?—I have seen it several times, but I could not say how often.

3253. How often has the penstock been opened when you have seen it?—I could not say, but I have noticed it when I was on the water.

3254. (*Sir John Coode.*) When you speak of the penstock at North Woolwich, I suppose you mean the penstock at Barking Creek?—There is a penstock at North Woolwich which contains the sewage of North Woolwich and the sewage of part of East Ham, which is emptied in the river, I think, every 24 hours.

3255. From about what population would the sewage drain into this penstock?—From the whole of North Woolwich and a portion of East Ham.

3256. (*Sir John Coode.*) Have you any evidence as to the population draining into this penstock?

3257. (*Mr. Michael.*) We shall be able to give you the entire details, but it has nothing to do with our sewer.

3258. (*Mr. Beaumont Morice.*) It is within the metropolitan district, I think.

3259. (*Mr. Michael.*) A portion of it is not in the metropolitan district.

3260. (*Mr. Lumley Smith.*) The outfall is.

3261. (*Mr. Beaumont Morice to the witness.*) You say that all that you know is down as far as Tripcock Point; that is nearly opposite Barking, is it not?—Nearly opposite Barking.

3262. And it was opposite Tripcock Point that the "Princess Alice" was run down?—Yes.

3263. You say that coming along Gallion's Reach, up to Woolwich and Charlton Piers, is where the bodies that you have to do with are found?—Yes, principally.

3264. And you say that you find that the bodies which are taken out along that part of the river very soon become discoloured?—Yes, they become quite black.

3265. (*Chairman.*) The bodies which you describe as being blistered you find somewhere near Charlton Point?—In Gallion's Reach, more so than in any other parts.

The witness withdrew.

*Capt. G. B. Lynch.*

Captain George Benjamin Lynch called in; examined by Mr. Beaumont Morice.

3266. I believe you are the principal dockmaster at the Gallion's entrance of the Albert Docks?—Yes.

3267. How long have you known the Thames?—I recollect it well for 40 years.

3268. Do you remember before the outfalls were made?—Yes.

3269. Can you tell us what was the state of the river before that time?—It was sometimes bad and sometimes pretty good. We used to dip our water when we lay off the Custom House, in steamers. I have known it to be a little bad in the summer time, but at other times it was very clear.

3270. Since the outfalls have been made, have you noticed any difference at all?—Yes, the water has been thicker.

3271. Is there anything else?—The accumulation of the mud on the banks is blacker, I consider.

3272. Is there any smell?—Yes, it smells very badly in the hot weather; you do not observe it much in the cold weather.

3273. (*Chairman*). Of what part of the Thames are you speaking?—Between the Victoria entrance and Gallion's entrance.

3274. (*Mr. Beaumont Morice*). That will be from Woolwich, down Gallion's Reach to Tripcock Point?—Yes.

3275. Have you noticed any alteration with regard to the mud about the entrance of the Albert Dock?—Yes, frequently. The water is black at times on the flood tide; you will see black water coming through the piles of the pier heads.

3276. Has there been any increase of this in the last few years?—Yes, I think so, from the accumulation of the mud in the basins of the docks.

3277. Have you more difficulty now in clearing it away than you used to have?—In the Albert Dock it has accumulated very fast in the last two years. The dock has been opened a little over two years, and there is a great deal of mud in that basin.

3278. Have you ever noticed any ill effects from this stuff about the docks?—I have found the men complain of the smell of the water at times.

3279. Do you ever use the water for anything now?—Oh, no.

3280. Why not?—It is not fit.

3281. Why is it not fit?—It is discoloured and dirty.

3282. (*Chairman.*) Is it the colour that makes it objectionable?—And it is thick also.

3283. Have you any other reason for not using it?—There is a sort of oily nature or appearance on the surface of the water at times.

3284. Have you any other reason for not using it?—From knowing that it is dirty and thick, we should not use it for any purpose at all.

3285. (*Mr. Beaumont Morice.*) Have you ever noticed any solid matter floating in the water?—Yes, frequently.

3286. Can you tell us what it has been?—Filth from the closets and that sort of thing.

3287. That you have seen?—Oh, yes.

3288. Often?—Occasionally.

3289. Have you ever noticed the sewage passing up the river?—Yes; the black streaky marks in the tide way.

3290. Can you tell us from your own observation at what time the sewage generally comes out of the river?—I have noticed the discolouration in the water at about half flood.

3291. Have you ever seen any dead fish about the banks of the river?—Yes, frequently.

3292. When did you last see them?—Last summer.

3293. What were they?—Eels and small flounders.

3294. Did you notice them at any particular time of the year?—In the summer months.

3295. Have you often seen them?—Whenever you see eddy tides, at the time the tide is running up generally.

3296. That is the eddy tide inshore, is it not?—Yes; you see these things in where the tideway is.

3297. Is the mud that is deposited in the docks now different from what it used to be some years ago?—Yes, I think it is of a blacker appearance.

3298. Is there any other difference?—It smells very much.

3299. Do you know any of the factories on the shore in that neighbourhood?—Yes, there are several between the Albert entrance and the Victoria entrance.

3300. Do they smell at all?—Yes, a little.

3301. Is there any difference between their smell and the smell of the sewage that you have told us about?—Yes, I think there is a difference.

3302. You cannot mistake one for the other?—I think there are nitro-phosphate manure works; that is about the strongest smell.

3303. That you are able to identify?—Quite so.

3304. Have you ever felt any ill effects from this yourself?—Not particularly.

3305. Have you felt any sickness?—Just a very little.

3306. Have any of your men felt it?—Yes, I have heard them complain. I have seen men sick and known men to be sick from it. It will affect some men more than others.

Cross-examined by Mr. Bidder.

3307. You did not inquire, did you, what these men had been doing or having previously?—They had been working at the lock side or the pier head.

3308. You did not know where they had spent the previous evening?—No.

3309. You have never been sick?—No, not really sick from that cause.

3310. Did I rightly understand you to say that you have observed an alteration at the entrance to the Albert Docks in the condition of the mud and the amount of mud in the docks, of recent years?—Yes, I think so.

3311. Am I not right in this, that those docks were only completed two years ago?—They have been opened two and a half years.

3312. And therefore, the only time during which you can draw any comparison as to the state of the stream or the state of the mud in the basin of the Albert Docks is within the last 2½ years?—Yes. I can compare it with the Victoria entrance.

3313. Which is in quite a different part of the river?—Yes, higher up.

3314. You are speaking now of what takes place at the Albert Dock entrance as compared with what used to take place at the Victoria Dock entrance?—

3315. (*Chairman.*) It is, as I understand, one dock with two entrances from 2½ to 3 miles apart?—Yes.

3316. (*Sir John Coode.*) What is the distance of the Albert Dock entrance from the northern outfall?—It is about three quarters of a mile, I should think.

3317. (*Mr. Bidder.*) And the distance of the Victoria Dock entrance from the northern outfall is about 3 miles?—Yes, a little over 3 miles.

3318. So that when you talk about there being more mud, what it comes to is this; that you find more mud at the Albert Dock entrance than there used to be at the Victoria Dock entrance?—The basins accumulate the mud faster, I think. The mud accumulates in both basins more than it used to accumulate.

3319. Have you ever heard it suggested that the Albert Dock entrance is put in a place that makes it very liable to be mudded up?—It is an eddy tide there on the ebb-tide.

3320. And, in point of fact, so liable is it to be mudded up, that you have had to make two great horn works; that is part of the design, is it not, to keep the mud from the dock entrance?—There are two pier-heads; but that does not keep the mud out.

3321. But that is what they are intended for, is it not?—I think not; I think they are for docking purposes—for docking the ships.

3322. It was hardly necessary to have gone so far into the river for that purpose. How long have you known the Victoria Dock?—Since it was opened.

3323. Was not the Victoria Dock always considerably troubled with mud?—Yes.

3324. When were the Victoria Docks opened?—In the year 1855.

3325. And they were always from the beginning very much troubled with mud?—Yes, we had a little mud.

3326. And very large quantities had to be dredged up and sent away in barges?—Yes.

3327. I will not ask you much about the flounders in the river; but there are a good many fish in the Victoria Docks, are there not?—There used to be.

3328. And there are now?—I think not.

3329. They catch jack there, do they not?—In former years they did; I do not think there is any fishing going on there now.

3330. Are you quite sure?—I would not be quite positive.

3331. How long is it since you have known people

*Capt. C. B. Lynch.*

21 Nov. 1882.

come to the Victoria Docks for a day's fishing?—I have not seen any there for these five or six years.

3332. When you say that you have noticed the sewage on the flood tide, I understand that what you have noticed is a discolouration of the water?—Yes.

3333. Do you say that you have seen that at half flood?—Yes.

3334. When did you last see it at half flood?—A month or two ago. In the hot weather it shows most. I saw it in August.

3335. Do you know North Woolwich?—Yes.

3336. Do you know the penstock there?—No, I do not.

3337. Do you know the place where the sewage discharge from East Ham and North Woolwich is?—No, I do not.

3338. Have you never heard of any sewage discharge there?—No; I have heard of the overflow water discharge.

3339 You are close to the Beckton Gasworks, I believe?—We are.

3340. Do you know anything of the arrangement for getting rid of the refuse from the gasworks?—No, I do not.

3341. Did you ever see a sewer there?—No.

Re-examined by Mr. Beaumont Morice.

3342. Vessels do not dock on the ebb tide, do they?—Very seldom.

3343. Then those piers are made for vessels coming upon the flood in order that they may go into the dock all right?—Yes, they are; those piers are for the express purpose of docking.

3344. And, notwithstanding that, they do not keep out the mud sufficiently?—No.

Examined by the Commission.

3345. (*Chairman.*) How long have you been connected with the Victoria Docks?—Since the opening of the Victoria Docks; 27 years.

3346. You have been asked whether there has not been a great deal of dredging necessary in the docks when did that begin?—We have been dredging in the Albert Dock basin this last month.

3347. That is quite a new dock, is it not?—Quite a new dock.

3348. But Mr. Bidder asked you whether you have not been for a long time obliged to dredge or to clear out the mud in the Victoria Docks?—Yes; about every three months we dredge the basin out there.

3349. (*Mr. Bidder.*) The witness said, in answer to me that they have done so, from the first, about every three months.

The witness withdrew.

Mr. James Henry Showell called in; examined by Mr. Beaumont Morice.

*Mr. J. H. Showell.*

3350. I believe you are an inspector of the Watermen's Company, and you live at Greenwich?—Yes.

3351. You have a district down the river, have you not?—Yes, boarding barges and craft on this river.

3352. On behalf of the Watermen's Company?—Yes.

3353. What is your district?—From the top of Limehouse Reach to Erith, or a little below.

3354. What do you board these craft for?—To see that the Act of Parliament is carried out.

3355. How many years have you been on the river?—It is 24 years on the 13th January since I was apprenticed on the river.

3356. And you know the river from Greenwich down to Erith or Gravesend pretty well?—Yes.

3357. Do you remember the outfalls being opened at Crossness and Barking?—Yes.

3358. Do you remember the river before that and since?—Yes.

3359. Is there any difference in the water?—Yes, very much.

3360. What difference is there?—The filthy state of it, the great amount of sewage in it, and the difference in the colour of the water.

3361. Is there any smell from it?—Yes, there was the summer before last; last summer it was not so bad. It was in the summer of 1880–81 particularly that I noticed the water being so bad.

3362. Have you ever noticed the sewage in the river specially?—Yes.

3363. How do you notice it?—By the thickness of the water; and by the mud, which is in a very bad state to what it used to be; and by the dreadful stink that there is attached to it.

3364. Take the mud all up on the south shore from Erith say up to Tripcock Point, what is the difference between the mud now and what it used to be?—Formerly it used to be of a whiter colour than it is now; it is more of a black colour at the present time.

3365. Is there any smell about it?—Yes, it stinks very much.

3366. Do you remember when the Dutch eel boats used to come off Erith?—I do not remember them so well off Erith, only once I remember bringing a freight of eels in a corfe.

3367. You had to do with them, had you not?—Yes.

3368. How long ago was that?—From the time I was apprenticed at the age of 14.

3369. How many years ago is that?—About 10 or 11 years ago was the last time that I worked for them.

3370. Where did you work for them then?—I first worked for them at Gravesend, lying at the "Lobster."

3371. What did you do?—The vessels used to come from sea and lie at the "Lobster," and we used to work the eels out from vessels in boxes, and bring them up to market every night.

3372. Where do they lie now?—At Hole Haven.

3373. Has anybody told you why they lie down there?—I knew from my own experience.

3374. But you have never been on those boats yourself?—I have worked for them and brought the eels out of the vessels.

3375. And, as a matter of fact, you know that they have been lying down at Hole Haven?—Yes.

3376. Have the people there told you why they were lying at Hole Haven?—It came under my notice principally to arrange the shifting of the vessels down at the time, on account of the water being so bad.

3377. Nobody told you anything?—Nobody told me anything. The Dutch people listened to us because of our knowledge of the water.

3378. (*Chairman.*) It was by your advice that they lay down there?—By my advice as well as that of other watermen.

3379. (*Mr. Beaumont Morice.*) And they took your advice?—They took my advice. There are three companies of those vessels working here, and there were other watermen working for the other companies, and we found that the eels would not live.

3380. So they went down to Hole Haven?—Yes.

3381. In which part of the river is it that this sewage smell is the worst?—The worst that I ever noticed was in Woolwich Reach, on the north shore.

3382. At what time of the tide?—Just on the young flood, just as the tide was making.

3383. That would be nearly low water, would it not?—The tide was flowing.

3384. Have you ever noticed any sewage matter or solid matter floating in the river?—Yes, frequently; and lots of things come down from the sewers as well.

3385. Sewage matter?—Yes.

3386. Have you ever suffered any ill effects from this stink?—In the summer of 1881 I was very sick one day at Woolwich, and I went ashore out of it. I told my men to row the boat to shore, and I got out of it.

3387. And I take it that when you went ashore you did not feel it?—No, I got away from it.

3388. Have you ever suffered from it so as to be unable to perform your duties?—No, I do not know that I have. I have felt very queer, but have still managed to perform my duties.

3389. Can you tell us, from your knowledge of the river, how far the sewage would go down the river on the ebb tide?—I should say about the lower end of Gravesend Reach.

3390. (*Sir John Coode.*) Do you say that from observation?—I should think we should drive that far from the outlet.

3391. But what makes you think it?—By driving. I have driven the tides many times about the river, and I should say from my own judgment that it would be there. I should say that we should drift about that distance with the tide; perhaps not quite so far; but I should think that the sewage would go faster than the tide, because a boat stands up against the wind.

3392. You ground that opinion upon the point to which you think a boat would drift with the tide?—Yes, I should think she would drift about that distance.

3393. (*Mr. Beaumont Morice.*) Have you ever drifted in a barge below Gravesend on the tide?—Yes, in a boat, I have been below Gravesend, but not to take particular notice.

3394. You have come up, have you not, from lower down the river, from the Nore way?—Yes.

3395. In coming up from the Nore into the river, can you tell the Commission what difference there is in the state of the water?—In Sea Reach you will find the water very clear, especially on the flood tide; but as you come up so you will find that it gets thicker and thicker from out of Sea Reach until you get up to the top of Limehouse Reach; and then you will find it will clear a little after that.

3396. Can you tell us at what point you begin to notice that it changes?—You would notice it as you entered the Lower Hope, coming into Gravesend Reach.

3397. Have you ever noticed any settlement of the sewage up and down the river?—Yes, frequently along the shores in the different bights.

3398. Has that been more so within recent years or not?—Yes, more so of recent years.

3399. Before the outfalls were opened was there anything like the smell from the mud that there is now?—No, not down from that part of the river.

Cross-examined by Mr. Bidder.

3400. How old are you?—Thirty-eight on the 10th of next January.

3401. To begin with the Dutch eel-boats, I understand that they used to stop at Erith, and the watermen recommended them to go to Hole Haven?—They stopped at Erith before my time.

3402. You never knew them stop at Erith?—I once towed a corfe with eels from Erith up to London.

3403. When you began, the Dutch vessels used to stop at Hole Haven?—The very first voyage that I ever had was from Gravesend and finished at Hole Haven.

3404. How far is Gravesend from Hole Haven?—about eight miles.

3405. When did you first go to Hole Haven?—I do not know the year; it was when I was apprenticed, and certainly after the sewers were let into the river.

3406. When were you apprenticed?—I was apprenticed three days after I was 14.

3407. How long were you apprenticed?—Seven years.

3408. Then you ceased to be an apprentice 17 years ago?—Yes.

3409. That is just about the time when the outfalls were opened; and the Dutch boats, you say, went to Hole Haven whilst you were an apprentice?—Whilst I was working on the water. I have been working on the water all my life.

3410. Have you anything to do with the Dutch eel boats now?—No.

3411. Do you ever see them?—Yes, but I do not go on board of them. Of course I frequently see them on the river.

3412 You do see the Dutch eel-boats?—Frequently.

3413. When you say that they went to Hole Haven by your advice, you must have been very young to give advice?—I said my partners and the other watermen with me.

3414. I suppose the watermen get a better fare from Hole Haven than from Erith?—No, you cannot call it better, because we used to do it from Gravesend for 20*s.* for a single hand, and after we shifted to Hole Haven we had 25*s.* for two hands; so that it was against our interest.

3415. Do you ever see the Dutch boats on the river?—Yes.

3416. You see them going up the Pool?—Yes, frequently; two came up last week with eels in them alive.

3417. Are the eels in the Pool alive?—Yes, they always were from the time I was an apprentice, in the winter time.

3418. And that is so now?—Yes.

3419. Those eels of course are carried in the well?—Yes.

3420. And I suppose that if one took the trouble to go down to Billingsgate or wherever they lie, one would see those boats in tiers now in the river with their wells full of eels?—Yes; there are some there now to-day. At this time of the year they always come up in the winter time.

3421. You have spoken of the smell in the river; I understand that the place which you identify as being that where you have detected the most distinct and offensive smell is on the north shore at North Woolwich?—Yes.

3422. Was it near the ferry pier?—Close to the pier.

3423. And just about ebb-tide?—No, on the young flood.

3424. Do you know the Penstock at North Woolwich?—Yes, just below Henley's place.

3425. How far is that above the ferry pier?—That I suppose is 500 or 600 yards; but on the flood tide, if anything was coming out, it would certainly go above where I was.

3426. I did not ask you that; I asked how far off it was. Have you ever seen the sewage discharged out of that?—No, it is under water at low water.

3427. It only discharges near low water, does it?—I do not know what time it discharges; I never noticed that. You cannot see the outlet; the tide never leaves it; it is an iron pipe that goes down into the river.

3428. Have you heard complaints about it?—No.

3429. Do you know the Beckton Gasworks?—Yes.

3430. Did you ever see any sewage coming from there?—No. I never did.

*Mr. J. H. Showell.*

21 Nov. 1882.

3431. Have you ever seen any pipe or sewer at the Beckton Gasworks?—I do not know that I ever noticed any.

3432. You never smelt anything coming from them?—As you go by there you can smell the gas liquor that they are loading the barges with.

3433. Have you seen the liquor come into the river?—No.

Re-examined by Mr. BEAUMONT MORICE.

3434. It depends a good deal upon the time of the year when the boats come up with eels, does it not?—Yes.

3435. Does it not depend upon the amount of fresh water that is coming down the river?—Yes, in winter time there is always a good down tide with plenty of fresh water, and the eels would be better in London than they would be even at the top of Sea Reach.

3436. You know the sort of wells that they have in those boats?—Yes, they are copper wells with very small holes in them.

3437. Open to the river?—Open to the river.

3438. You say that you do not know anything about the sewage at Barking or at Beckton?—I do not.

Examined by the COMMISSION.

3439. (*Dr. Stevenson.*) Do the eel-boats come up in the summer in that way?—No, they could not come up in the summer.

3440. Why not?—On account of the badness of the water; it would turn all the eels up.

3441. (*Chairman.*) What makes you say that it would do so?—I have seen that it has done so.

3442. But it does not do so in the winter?—No.

3443. (*Mr. Bidder, through the Commission.*) In the olden time, when you were an apprentice, when they stopped at Erith used they to come up in the winter time?—Yes, all the year round, ever since I can remember, and I have heard people say before me, that they always came up in the winter time.

3444. (*Chairman.*) They come up in the winter time now; but did they come up in the summer time?—No; they used to work the eels at that time of day up in corves through the water from Erith right up to London. Then when the water began to get bad we used to bring them up in boxes from Gravesend, and that is the way they bring them now from Hole Haven.

3445. (*Mr. Bidder.*) Towing them?—No; bringing them up in the boats. They are not in the water now; they are in dry boxes.

3446. (*Dr. de Chaumont.*) Not even during the winter?—We never work them up in the winter from below, because they came to London as they do now.

3447. Then are the eels in the wells now?—Yes, in London, as they lie now.

3448. Have they been in the wells all the way up?—Yes; they tow up by steam and the vessels come through the water so fast that it is does not give the sewage or any filth the opportunity of settling in the wells; they keep getting fresh water.

3449. (*Chairman.*) In point of fact the eels remain in the wells, and they are towed up to the market in the winter time.

3450. (*Mr. Bidder.*) About how many tons of eels are there in one vessel?—About 12 tons. We use to bring out 12 boats of eels, and we reckoned each boat of eels was about a ton.

3451. And those eels as they lie at Billingsgate are supplied with river water?—Yes.

3452. And are living for days on it?—Yes, but they are better at low water than they are on the flood.

3453. (*Sir John Coode.*) You told us that you thought the sewage would extend as far down as the lower end of Gravesend Reach, and that you came to that conclusion because a boat would drift so far; have you ever seen any discolouration of the water as far down as that?—I have noticed the fact of the water being thick there

3454. Thick with what?—With darkness in the water; not clear like it used to be.

3455. Then you say that the water is different in appearance at the lower end of Gravesend Reach from what it used to be?—Yes, in my opinion.

3456. (*Dr. de Chaumont.*) Is it offensive at all to the smell?—Not at this time of the year; you would not notice it so much now.

3457. (*Chairman.*) Is there any sewage discharged into the river at Gravesend?—I think there is somewhere above the canal.

3458. Would that account for the discolouration that you speak of?—I do not know that it would much. That sewer was there when our vessels used to lie there, and it never affected the eels.

The witness withdrew.

Mr. JAMES WILLIAM ROZIER called in; examined by Mr. BEAUMONT MORICE.

*Mr. J. W. Rozier.*

3459. I believe you are the chief inspector of the Watermen's Company?—Yes.

3460. You have been 18 years in the service?—I have.

3461. Will you tell us shortly, do you remember the river before the outfalls were open?—Yes.

3462. What is the difference between then and now, if any?—In the year 1860 I lived at Dagenham, just opposite Crossness. I lived there, I should think, about 12 months. I was living there nearly all the year 1860.

3463. Since that time what part of the river have you been on chiefly?—I have been on all parts of the river.

3464. Do you know the part from Woolwich to Gravesend?—Yes.

3465. Has there been any difference in that since 1860?—Yes, a wonderful difference.

3466. In what way?—There has been a difference in the state of the water; the water has been very bad since then.

3467. In what way has it been bad?—I should lay it to the sewage.

3468. (*Chairman.*) You are not asked what you would lay it to; but what makes you say that it has become bad?—The water has become a different color.

3469. (*Mr. Beaumont Morice.*) Is there anything else besides the colour?—Yes, the stench as well.

3470. Have you noticed anything else about it?—Those are the two principal things.

3471. The colour and the stench?—Yes.

3472. Have you ever noticed bodies that were taken out of the water?—Yes.

3473. In what state were they?—They were black.

3474. Was there anything about their clothes, any mud, or anything of that kind?—Yes, slime. At the time of that sad disaster to the "Princess Alice" I was there every day, and I had a good chance of seeing all the bodies that were picked up, or the best part of the bodies, fetched on shore.

3475. What were they like?—They were black, with filth on their clothes, a kind of slime.

3476. You know the mud on the foreshore down the river; is that different from or like the mud that there used to be?—It is quite like ink in a manner of speaking, quite black.

3477. Is there any smell with it?—Yes; when the weather is warm in the summer time a very offensive smell comes from the mud.

3478. At what time of the tide is this smell the worst?—On the ebb tide, when the tide is any way down drawing towards low water.

*Mr. J. W. Rozier.*

21 Nov. 1882.

Cross-examined by Mr. BIDDER.

3479. When you were living at Dagenham for a twelvemonth what were you doing?—I was taking the fish refuse away from Billinsgate Market.

3480. What did you do with it; where did you take it to?—It went on shore at Dagenham to make manure with.

3481. And at that time there were no offensive smells of any kind on the river?—No; the worst smell that I had to contend with was the smell from what I was taking there at that time.

3482. Possibly you used to row your barge?—It was what they call a lug-boat.

3483. You used to take it full of refuse from Billingsgate?—Yes.

3484. And when you were sitting with this refuse in front of you, you did not detect any smell from the river?—No, only the smell that I had in the boat.

3485. You could smell that?—Yes, quite plainly.

3486. Have you tried the river recently with a boat load of fish refuse to see if you could smell anything else?—No, I have not been engaged in the work since then.

3487. Now about the wind. Where have you been smelling the wind lately?—When I have been in one of our skiffs I have noticed it with the steam boats going down at low water time, the paddle wheels stirring it up.

3488. Did you ever try to smell the mud in the olden days?—Not particularly.

3489. But there again I suppose your fish refuse was a considerable protection to you, was it not?—Well that was a stench, I must admit.

The witness withdrew.

3490. (*Chairman.*) It is the feeling of myself and my colleagues that we have had a great deal of this kind of evidence, and I do not know that you strengthen your case, Mr. Morice, by bringing in more evidence of the same kind. At the same time, of course we do not wish to dictate to you in any way as to how you should conduct your case. Recollect, we are not a jury; but most of the gentlemen about me are gentlemen of great experience and technical knowledge who are able to appreciate this kind of evidence; and we should like to come to something nearer the heart of the matter.

3491. (*Mr. Beaumont Morice.*) I am much obliged to you for the suggestion. A large amount of evidence has been furnished to me to prove the points which I have submitted to the Commission, and it is undoubtedly my case here on behalf of the memorialists who, of course are a somewhat large body of persons, that there is a great deal of evidence to this effect, and there are a large number of persons who are persuaded that this pollution is a nuisance, and has been caused by the sewage from Crossness and Barking. At the same time I have different classes of evidence, and if it meets the views of the Commission, I do not wish to go further with any particular class than the Commission may think fit. But having regard to the number of witnesses, and the various classes of evidence which have been tendered to me, I think, that acting on behalf of the memorialists, I am hardly in a position to withdraw any particular class of evidence from the Commission until the Commission think fit to suggest the same to me.

3492. (*Chairman.*) I think that is very fair; but the fact is that we have had a great deal of this kind of evidence. We do not doubt the respectability and *bona fides* of your witnesses, but we are able to appreciate the weight that is justly due to their evidence, and we doubt very much whether you would strengthen the case by calling three times the number of witnesses into this room for the purpose of repeating what their predecessors have already told us. If you have evidence of a different class to lay before us we shall be only too ready to receive it.

3493. (*Mr. Beaumont Morice.*) Perhaps you will allow me to say that the great point that the memorialists have in view is to show the Commission how widespread the experience and the feeling on this matter is: and that being so, I really think that the Commission themselves would hardly feel satisfied, unless a variety of evidence were brought before them, in order to show the extent to which this feeling exists.

3494. (*Chairman.*) How many more witnesses have you of this character?

3495. (*Mr. Beaumont Morice.*) At the moment I do not think that I have above one or two more of that character, because I was thinking, with your permission, of taking witnesses of a different class to-morrow.

3496. (*Chairman.*) We shall examine the river very carefully ourselves.

3497. (*Mr. Bidder.*) If I might throw out a suggestion to my learned friend, instead of calling a lot of very respectable, but for this purpose, uneducated gentlemen, to say that the mud is brown or black or yellow, he can bring scientific gentlemen to tell us what the mud is.

3498. (*Mr. Beaumont Morice.*) The persons who are affected and who are best able to speak upon a matter of this kind are persons of the class to which my learned friend refers.

3499. (*Chairman.*) Unquestionably; but we have had a great many witnesses who have already spoken on that subject; so many that we must see that their complaints are very well worthy of attention. Whether you would strengthen your case by calling as many more who will come and tell the same story seems to us more than doubtful.

3500. (*Mr. Beaumont Morice.*) I am much obliged to you, sir, for the suggestion, and I will consider it.

Adjourned to to-morrow at 1 o'clock.

# SEVENTH DAY.

## Wednesday, 22nd November 1882.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary.*

CAPTAIN JAMES HUSSEY called in, and examined by Mr. BEAUMONT MORICE.

3501. I believe you are the principal dock-master of the East and West India Docks?—Yes.

3502. How long have you been there?—32 years.

3503. Will you tell us shortly whether there has been any difference in the accumulation of the mud at the entrance of the docks in the last few years?—

*Capt. J. Hussey.*

22 Nov. 1882.

*Capt. J. Hussey.*
2 Nov. 1882.

There has been an enormous difference in the last three or four years, and especially this year.

3504. (*Professor Williamson.*) Do you mean that there has been more mud deposited?—Yes.

3505. (*Mr. Beaumont Morice.*) Do you remember when the outfalls were opened?—Yes.

3506. Is there any difference in the accumulation of the mud between the time before the outfalls were opened and since?—At first there was a decrease in the mud after the outfalls were opened.

3507. And since then what has happened?—Since then it has been gradually increasing, working its way up.

3508. Will you tell us what sort of mud it is?—It has a very large proportion of sewage mixed with it. I may say, for instance, that three years ago, say in 1879, 69,000 tons of mud raised cleared the whole of our docks and basins, which I suppose cover an area of about 120 acres. This year I have already raised 90,000 tons, leaving an accumulation of something like 70,000 tons; in fact I have been obliged to employ a contractor to do one basin, because the mud has overpowered me.

3509. And you say that it is sewage now?—A large proportion of it is sewage. My house is within 20 feet of the river, and after a still night, when there is not much motion, when the mud settles on the banks, the stench from it is something awful in the summer time.

3510. Are there any factories near where you are on the land?—No.

3511. Have you ever suffered any illness?—I have not personally, but my grandchildren and my family who are in the house have suffered. They lived there in the summer time while I was away on my holiday, and they were taken ill; both my son-in-law and his children.

3512. Were they ill while you were there at all?—Yes, when I came back, because they telegraphed for me, and I came back directly.

3513. And you saw them?—Yes.

3514. Can you tell us, from any observation of your own, at what time the sewage passes up by the docks?—It is working up very gradually. It took, I should think, nearly two years, or more than that, say 2½ years, to reach our place from the outfall.

3515. Can you tell us at what time of the tide the sewage comes out from the outfall?—I think it is first quarter ebb.

3516. (*Mr. Bidder.*) Are you down there?—No, I am not.

3517. (*Mr. Beaumont Morice.*) You have not seen it come out yourself?—Yes, I have. Where we land our mud adjoins the pumping station at Crossness.

3518. Have you noticed the sewage come out into the river?—Yes.

3519. Can you tell the Commission at what time of the tide it comes out into the river?—I should say about a third or a quarter ebb.

3520. (*Professor Williamson.*) You mean the first quarter of the ebb tide?—Yes.

3521. (*Mr. Beaumont Morice.*) Have you seen the sewage further up the river at all than the outfall?—We have got it at the back of my house.

3522. How far would that be from the outfall?—Eight miles; and we have it also in our locks, because I am always dredging, and of course I see it every day.

3523. How can you tell that what you are dredging is mixed with sewage?—I can tell that it is mixed with sewage by the effluvium of it; and besides, having so many years' experience of mudding, I can tell by the appearance of it, by the slimy greasy look it has, and by the feel.

3524. Have you ever seen the sewage bove your place?—Yes, it has got up now, I should say, as far as Limehouse.

3525. (*Chairman.*) You have seen it as far up as Limehouse?—Yes.

3526. (*Mr. Beaumont Morice.*) When was it that you saw it at Limehouse?—About a week ago. I tried some of the mud there because our docks extend up to Limehouse.

3527. And you found it mixed with sewage?—Yes; that is the way I test it—by the smell and the feel.

3528. Can you tell us whether the flood tide is stronger than the ebb?—It is.

3529. Would it therefore, or not, bring anything further back than the point from which it started on the ebb?—Yes; it goes some considerable distance down, but the flood tidal wave will overpower it. It is a singular thing that, although the ebb tide runs one hour longer than the flood, the flood seems to overpower the ebb tide. In fact, I have formed an opinion that it will reach up here in about 18 months' time.

3530. (*Mr. Michael.*) From now?—From now.

3531. (*Mr. Beaumont Morice.*) Have you ever had any of the actual sewage from Barking in your docks?—Yes. I suppose it all comes both from Crossness and from Barking too. I cannot distinguish them.

3532. Is there any special time more than another when you have any?—No. Sometimes, when there is an accident at the Barking outfall, they pump it into the River Lea, and then we get a dose of it.

3533. Has that ever happened?—Yes, some stoppage of the pumping station at Barking.

3534. (*Chairman.*) That is up in Barking that they pump it into the Lea?—No; it is at the pumping station at Bromley where they pump it into the Lea.

3535. When there is an accident at Barking, then their sewage, you say, is put into the Lea, and you get a dose of it?—Yes.

(*Mr. Lumley Smith.*) The storm overflow is at Bow Creek in the River Lea.

(*Mr. Michael.*) That is a totally different matter.

3536. (*Mr. Beaumont Morice to the witness.*) On those occasions you have an unusual quantity of it?—Yes.

3537. Have any of your men, to your knowledge, had any illness owing to this?—There is only one man who has. I do not know it from my own personal knowledge.

3538. Can you tell us, from your own observation, how far, up to two years ago, the sewage extended up the river?—No, I cannot. Till it came to our place I did not notice it.

3539. Have you any means of knowing, from your own experience, how far it has been up the river, say from year to year, lately?—According to what I have noticed myself, I have calculated, and it is my opinion, that it works its way higher up at the rate of about three-quarters of a mile a year.

3540. (*Professor Williamson.*) Could you give us some particulars of the observations which you have made upon that point; where it was in some one year, and where it was in some subsequent year?—It seems to me gradual. Our place extends from Blackwall to Limehouse, about 3½ miles; and I have calculated from that, and from the first time I noticed the sewage, which was about the year 1879, up at our docks.

3541. (*Chairman.*) What point had it reached in 1879?—The East India Docks.

3542. Did you notice it the following year?—I did.

3543. How far had it reached the following year?—About 200 yards, I reckon, from our south dock entrance at Blackwall.

3544. Then in the year after that, did you notice it again?—I noticed it again.

3545. What did you notice in that year?—I noticed that it had got to a dry dock about three-quarters of a mile further up, above Cubitt Town Pier, opposite East Greenwich.

3546. Have you noticed whether it has got higher than that since then?—Yes; it is up at our Limehouse entrance of the south dock, and that is as far as my observation goes. I have no business any further.

3547. (*Mr. Beaumont Morice.*) That is a considerable way higher than it came in 1879?—Yes.

Cross-examined by Mr. Bidder.



3548. You are dock-master, I understand?—I am the principal dock-master.

3549. I should like to know where your house is that you speak of, and that you say is close to the river?—Close to the Blackwall entrance to the West India Dock.

3550. Would you mind pointing it out on the map?—Just here (*pointing to the map*).

3551. I understand you to say that not only is the sewage poured in at Barking, but that sometimes, when there is an accident to the pumping station at Barking, they turn it into the Lea?—Yes, that is what I say.

3552. You say that, of course, because you know it is a fact?—Yes.

3553. You are quite certain of it?—Yes.

3554. Should you be surprised to hear that there is no pumping station at Barking?—I did not say at Barking; I said at Bromley. We call it the Barking outfall; I do not know whether I am right in the term; it may be at Barking, but we call them the Barking outfall and the Crossness outfall.

3555. You certainly said, when there was an accident at Barking Pumping Station?—Well, at the Barking outfall; that is the name it goes by in the river.

3556. You do not mean anything at Bromley?

3557. (*Chairman.*) You said that when there is an accident at the Barking outfall some pumping takes place at Bromley?—Yes, at Bromley; that is the overflow pumping station.

3558. (*Mr. Bidder.*) What kind of accidents happen at Barking?—I do not know what kind of accidents they are. I know there was a stoppage at Barking at that time, and I can assure you that it came into the East India Dock in one solid mass of sewage; for I was there.

3559. Not liquid?—Yes, liquid of course, or else it would not flow.

3560. The Lea comes into the river close below your dock entrance, near your house?—Yes.

3561. Are you aware, or can you tell the Commission, whether as a matter of fact the sewage of all West Ham and Stratford is discharged into the Lea near its mouth?—I do not know for a fact.

3562. Do you see on the map places labelled as West Ham outfalls?—Yes.

3563. Are you aware that there are outfalls there?—No.

3564. You never heard of that?—No; I do not know where it would go to.

3565. We can all form a judgment where it would go to; but you personally know nothing about that?—No.

3566. I understand you to say that until the year 1879 a very moderate quantity of dredging sufficed to clear your dock?—Just as much as we could do.

3567. 69,000 tons?—Yes.

3568. And this year you have had practically more than double that quantity to deal with?—Yes. I did not say that it was all sewage, you understand.

3569. I did not ask you that question. You attribute that, I understand, to the sewage having come up from the outfall?—Yes, a good part of it.

3570. Then of course you mean us to understand that all the increase is due to the sewage?—No, I do not.

3571. Then what is it due to?—It is due, this year especially, partially to the sewage, but partially to the large number of heavy tides that we have had this year, bringing down a lot of land water and mud with it.

3572. There is no doubt that a great deal of mud has been brought down by that?—No doubt about it.

3573. It has been very exceptional this year?—Very exceptional.

3574. You said that it took $2\frac{1}{2}$ years to come up to that from Barking?—No, I do not think I said that. From one entrance to the other I think I said; from the Blackwall entrance to the Limehouse entrance, because I said I had no knowledge of it below.

3575. Then you account for that, as I understand you, by the fact, if it is a fact, that the flood tide is practically stronger than the ebb?—Yes.

3576. So that the sewage which is put in at Barking, though it is carried down towards the sea, comes up more than it goes down?—Yes.

3577. And in process of time works its way up the river?—Yes.

3578. And whatever is put into the river at Barking or Crossness gradually works its way up the river?—Yes.

3579. And that has been going on ever since the outfalls were opened?—Yes.

3580. Always working up little by little?—Yes.

3581. And, of course, accumulating in the upper part of the river?—Yes.

3582. Whatever has been put in at Barking or Crossness since the outfalls were opened?—Yes.

3583. When you tell the Commission that it took $2\frac{1}{2}$ years to come up to your entrance, and that now it has got up to Limehouse, I want to know the exact point that you mean it has got up to at Limehouse?—I mean that there is a proportion of sewage which has got up to Limehouse.

3584. You said that you recognised last week that it had got up to Limehouse?—That was not the first time I tested it.

3585. (*Chairman.*) You said that you had seen the sewage as far up as Limehouse, and that you tried some there a week ago; but you did not say that that was the first time you had seen it?—No.

3586. (*Mr. Bidder.*) How do you ascertain the fact of its reaching up as far as Limehouse?—By testing the mud, by smelling it, and by the feel. It has a different feel altogether from common mud; it feels slimy and greasy.

3587. That is what I am to understand you to mean when you say that you recognise the sewage, whether at your own docks at Limehouse or anywhere else, that you feel the mud and it feels greasy and slimy, and that you smell it and it smells bad?—Yes. I did not taste it.

3588. You also went further as regards the mud in your docks, and you spoke of the proportion of sewage mixed with the mud being large; how have you ascertained that?—By the colour of it.

3589. Is it lighter or darker?—Darker. It turns the mud black.

3590. What used to be the colour of the mud in your dock?—Sand colour.

3591. Is it now black?—It is black when it is stirred; when we raise it.

3592. And as to anybody suffering, you said very fairly that you had only heard of one man suffering, and that that was not within your own knowledge?—That is so.

3593. Have you men stationed down at Crossness?—Yes.

3594. I think you have a place where you shoot the mud?—Yes, adjoining the pumping station at Crossness.

3595. How many men have you stationed there?—I do not know. It is under the inspector of mudding. I think there are about 12 men.

3596. Do they live there?—Yes.

3597. And are those men employed for the purpose of barging down your mud; is it their business to go up and down to and from that place?—No; they are stationed there.

3598. Do they live on shore?—They live on shore.

3599. I think that place adjoins the outfall station at Crossness?—Yes.

Re-examined by Mr. Beaumont Morice.

*Capt. J. Hussey.*

22 Nov. 1882.

3600. Has there been any solid matter in this sewage that you have noticed above your entrance?—I take it up in my hand and feel it and smell it.

3601. But is there any solid matter in the sewage in the water; is the water thick, or is it clear?—The water is very thick. Of course, that is a great deal attributable to the large number of steamers that have been employed lately.

3602. (*Chairman.*) In point of fact, the water is thick?—Yes; it comes in very thick.

3603. (*Mr. Beaumont Morice.*) Have you ever noticed any lumps in it?—I have not.

3604. And it is because you have had to dredge it out that you speak about this increase of mud and sewage?—Yes.

Examined by the Commission.

3605. (*Chairman.*) You said that the mud in the dock was formerly sand colour?—Yes.

3606. When did it cease to be sand colour?—The first time I began to observe it was about the year 1876; but I did not take any particular notice of it till about the year 1879.

The witness withdrew.

Mr. George Frederick Fuller called in, and examined by Mr. Beaumont Morice.

*Mr. G. F. Fuller.*

3607. I believe you are a member of the firm of Messrs. G. and A. Fuller?—Yes.

3608. And I think your firm are dredging contractors to the Government?—Yes.

3609. Have you been in the habit of dredging for ballast in the River Thames?—Yes, for the last 20 or 30 years, for ballast and sand.

3610. In what part of the river have you been dredging?—From Woolwich to Gravesend.

3611. In the early part of the time, say 20 to 30 years ago, what did you get from the bed of the river?—We used to get clear sand, building sand, and ballast, at what they call Jenningtree Point.

3612. And at any other places?—At all the points down the river. There are six or seven other points between there and Gravesend. Fiddler's Point is the last one before Gravesend. The sand accumulates around each point when there is a tideway.

3613. May I take it, then, that practically at each point down the river you obtained sand?—Yes; we used to get it as near London as possible; but eventually we were driven right down, and we have now to go to Coalhouse Point, below Gravesend.

3614. Up to what time were you able to get sand at Jenningtree Point?—We began there.

3615. When did you cease?—Soon after the sewers were opened; I should think the first year after. In 1866, or something like that; we ceased to dredge at Jenningtree Point after the sewer was opened on the Crossness side.

3616. Where did you go to then?—To the next point. I forget the names; there are six or seven of them. Tripcock Point, I think, is the next one.

3617. That is opposite Barking?—Yes; they drove us down, year by year.

3618. When did you go away from there?—I cannot say exactly.

3619. (*Mr. Bidder.*) Tripcock Point is higher up the river than Jenningtree Point?—Tripcock Point is the first point; it is higher up than Jenningtree Point. We began at Tripcock Point.

3620. You said just now that you left Jenningtree Point and went to Tripcock Point?—The first point below the entrance below Woolwich is Tripcock Point.

3621. (*Chairman.*) You used to dredge at Tripcock Point. When did you leave it?—About 12 months after the Crossness entrance was opened.

3622. Then you went to where?—We went to the next point, that is Jenningtree Point. We worked at both those points at the same time, and then about 12 months or so after the entrances were opened for the sewage we had to get further down.

3623. Were you obliged to leave both the points at about the end of the year?—Yes, at about the end of the year. There are so many points that I confuse them.

3624. Having left Tripcock and Jenningtree Points, where did you next go to?—We came down to Coldharbour Point then.

3625. That is on the other side of the river, is it not?—Yes.

3626. (*Mr. Bidder.*) Is Coldharbour Point the point opposite Erith Bight?—Yes.

3627. Is that where you are now?—No; the Coalhouse, below Gravesend.

3628. (*Mr. Beaumont Morice.*) How long did you stay there?—They used to go and come, if I may explain it. Sometimes, when there was a good sluice of water down, a lot of water down from the upper river, there used to be sand that would last one, two, or three freights, and they would work that away and then go away again.

3629. (*Chairman.*) When were you first obliged to desert Coldharbour Point?—Three or four years ago, I should think.

3630. For three or four years afterwards you were able to work there unintermittently?—Yes, you might say that, until we were driven away.

3631. Then afterwards you were able to come back occasionally when a heavy flood brought down sand from the country?—Yes; when there was a good flush out it seemed to leave two or three freights of sand, and the men would work that away.

3632. But for three or four years after going down to Coldharbour Point you were able to work there unintermittently?—Yes.

3633. Why did you leave that place?—Because we were driven away by the mud. Customers complained of the filth in the sand.

3634. (*Mr. Beaumont Morice.*) Then after three or four years where did you go?—To Crayfordness.

3635. That is on the south side?—Yes.

3636. When had you to go away from Crayfordness?—I worked, on and off, at Crayfordness for about 10 years. That somehow clears itself in some way.

3637. Crayfordness is the point below Erith, is it not?—Yes.

3638. Do you remember the year that you had to go away from there?—That is something like the other point. They can come back again and get a little there.

3639. (*Chairman.*) Down to the present time?—It is very dirty now.

3640. Do you ever go there now?—No; they will not accept it now.

3641. When did you cease altogether to go there?—We are not supposed to have got any sand from there these last two or three years.

3642. Where did you go to after that?—To Fiddler's Point.

3643. And when did you leave Fiddler's Point?—Within the last few years we have been driven down to Gravesend. Within the last four or five years we have got our sand between Fiddler's Point and Gravesend and Coalhouse.

3644. (*Mr. Beaumont Morice.*) Coalhouse is on the north shore, just beyond Gravesend, is it not?—Yes.

3645. (*Professor Williamson.*) Where is Fiddler's Point; is it opposite Greenhithe?—Yes.

3646. It is marked here "Stoneness"?—Yes, but

we have a name for the Point, and the men know it better by that name. It is called Fiddler's Reach. I am giving you rather the name that the men call it by, if we ask them where they get it from.

3647. (*Mr. Beaumont Morice.*) You say that you found the sand mixed with filth; will you tell us exactly, or as nearly as you can, in what way the filth lay on the sand?—The men had to wash it.

3648. (*Chairman.*) Did you see it yourself?—Oh yes; it is brought back to us, sent home in sample.

3649. In what condition did you find the sewage; was it mixed with the sand?—Yes, it was intermixed with the sand. You can smell it as well when it is dry, and it discolours it and turns it black.

3650. (*Mr. Beaumont Morice.*) Have you seen it brought up by the dredgers from the bed of the river?—Yes, we have it in our barges daily.

3651. What was the condition of the buckets or bags which brought up this stuff?—They have it in a large bag, and they lodge the bag, and they allow as much muck as they possibly can to run over the edge of the bag before they tip it into the barge's hold; and that is all filthy black stuff.

3652. The top of the bag is full of filth?—The top of the bag is full of filth; and they allow the thing to squeeze itself down, and the best part of the muck to run over.

3653. And you say that there is a smell from it?—Yes; it is very unpleasant indeed.

3654. Has that been the case at the different points down the river?—Yes, always the same as we have been going down. It got so bad at last that we were obliged to leave the different places. The customers would not have the sand, and therefore we were obliged to go lower down. It was only reported yesterday that the Gravesend sand was spoilt now.

3655. (*Chairman.*) Did you see it yourself?—No; but one of our men reported yesterday that the Gravesend sand was covered with filth to a depth of 18 inches.

3656. (*Mr. Beaumont Morice.*) Do you know, beyond what you have told us, the condition of the river in the upper part by Woolwich lately?—I know the condition outside both the outfalls.

3657. Do you know the upper part by Woolwich at all?—Our own premises are at North Woolwich. We have got about 1000 feet of frontage at North Woolwich, and that is in a dreadful state; it is covered with about 18 inches of this filthy stuff. That has accumulated in the last 18 months or two years; it seems to have got there since 1879, I think it was, when we took the place. In two or three years 18 inches of mucky, filthy brown or browny-red stuff has accumulated. The top of it is covered with a light brown sort of material.

3658. Is there any smell to it?—Yes, of course it smells; but I do not know that you would smell it now unless you took it up in your hand; but in the summer time it is awful.

3659. Is it different from the ordinary mud?—Yes, it is a different colour; it is a reddy-brown.

3660. Would you call it mud?—No, I should not.

3661. What should you call it?—Sewage.

3662. (*Mr. Bidder.*) Eighteen inches of sewage?—I do not say that there are 18 inches entirely sewage. The stuff is mixed with the mud, but it is coated with a light coat of sewage on the top of it.

3663. (*Mr. Beaumont Morice.*) Have you been in the habit of using this Thames water for the purposes of your business; for cranes and things of that kind?—Yes, for crane boilers; but we have been obliged to stop that within the last two or three years; we cannot use the Thames water for boiler purposes.

3664. Why have you had to stop it?—The water is so filthy.

3665. (*Professor Williamson.*) But what effect does that produce?—It makes the boilers prime, and it adheres to the tubes, and so burns the tubes out.

3666. (*Mr. Beaumont Morice.*) What have you had to do in consequence?—We have been obliged to have the water company's water laid on.

3667. That is an additional expense?—Yes, rather a large expense, because we are out of the way of the water, and we have had some thousand feet of pipe laid there.

3668. Have you ever suffered any injurious effects to your health from this sewage?—For two summers I was very poorly over it; both in July of 1880 and in July of 1881, when the temperature was so high; it was 97° at times in those months, and then the smell was very bad, and it affected me because I was there a fortnight.

3669. In what way did it affect you?—With sickness.

3670. Have you ever had any barges sunk in the river?—Yes, rather too many.

3671. The reason why I ask you that question is this: in getting them up again, in what state did you find them?—There is always a bad sediment on them above Gravesend, perhaps half an inch in a day or 24 hours.

3672. What is the sediment, so far as you can say?—Mud and sewage mixed together.

3673. You say that is above Gravesend. Have you ever had any experience below Gravesend?—Yes, we have had two or three below Gravesend; but we do not find the filth in the sunken barges below Gravesend that we do above Gravesend.

3674. Do you have any difficulty in getting men to attend to them in consequence?—Yes; they seem to require a good deal of refreshment before they will have anything to do with it.

3675. (*Mr. Bidder.*) Do you mean when they are raising barges?—No, when they are throwing muck out.

3676. (*Mr. Beaumont Morice.*) Do you find more difficulty in getting men for the work above Gravesend than below?—Yes.

3677. On what ground?—On the ground of the filth and the smell of the stuff.

Cross-examined by Mr. Bidder.

3678. You appear to carry on two businesses as I understand, dredging sand and dealing with mud?—Yes, they are two distinct businesses.

3679. You have spoken about barges above Gravesend being covered with mud and filth; are you old enough to remember the river before 1864?—Yes.

3680. Was there no mud in the river then?—Yes, but it was a different kind of mud; it was a whitey mud, as far as I can remember it, then.

3681. It did not smell at all?—No.

3682. And in your experience of the river before that date there were no offensive smells at all?—I will not say that; I say the water was very bad at times in very hot summers before the sewage came there. Sometimes the water was very bad and black.

3683. By-the-by, while it is in my mind, what was the nature of your illness which you spoke of in the summers of 1880 and 1881?—Sickness and unpleasant feelings. It turned my stomach, in fact, and I vomited.

3684. Where do you reside?—At Granville Park, Blackheath, but I am almost all day on the water.

3685. As regards the dredging at Jenningtree and Tripcock Points, as I understand, you were driven away from there because the mud came in those parts of the river where you were accustomed to get sand?—Yes.

3686. In point of fact, those are the mud banks that have been spoken about; one of them is right opposite the Crossness Reservoir, is it not, extending up to Jenningtree Point?—Yes.

3687. And the other one above Jenningtree Point?—Yes.

3688. And then there is a third one in Erith

*Mr. G. F. Fuller.*

22 Nov. 1882.

Bight?—Yes; and there is another very large one at Grays. We had a barge sunk last week, or a fortnight ago and they put her ashore in four feet of mud for us and that was a clean hard shore a few years ago. That is new to me.

3689. Whatever caused those mud banks has driven you away from those places?—Quite so.

3690. You said that as regards Crayfordness you went there, off and on, for some years, and you said the same of Coalhouse Point, I think?—Yes; when a flush has come down it has seemed to clear the muck off for a time.

3691. But there is another thing, is there not; it depends upon the tides whether the sand comes up and accumulates; the sand of course comes from seaward, does it not?—I do not think it does; I think it comes down with the wash.

3692. But it fluctuates, and always did fluctuate, and sometimes you have more sand at the points and sometimes you have less?—Yes, it would fluctuate no doubt.

3693. Do you think that the increasing traffic of the river, and the constant stirring up of the mud, has had anything to do with the additional dirt in the water?—No, because we have eight or nine feet of mud where we used to get clean good sand.

3694. You are again referring to the places that I have already mentioned?—Yes; the two or three upper points seem to be the worst.

3695. With reference to your place at North Woolwich, you say that there you have 18 inches of mud, which you call sewage, and you afterwards added that you do not mean that it is all sewage?—No, it is mixed.

3696. Did I rightly understand you to mean that there was a coating of sewage on the top?—Yes.

3697. How do you identify that?—By the colour.

3698. What is the difference in the colour?—Mud has a kind of white appearance at the top; the sewage is a reddish brown.

3699. They are of different colours. Now about the water in the boilers; can you tell me what water the river steamers use for their boilers?—Yes; but they have condensing engines; they condense their water; they use condensers.

3700. Do you know what water they use?—Thames water.

3701. (*Professor Williamson.*) Do you mean that they use surface condensers or injection condensers, because they are quite different things?—They use both. They use clear water to put into the boilers; they do not use this filthy water out of the river to go into the boilers; it would wear their boilers out in a very short space of time.

3702. Do you know that a great number of them use surface condensers, by means of which they can return distilled water to the boilers; I know that a great number of them do.

3703. (*Mr. Bidder.*) How long have you occupied these premises at North Woolwich?—Since the year 1879; and 18 inches have accumulated there since we took them in 1879.

Re-examined by Mr. Beaumont Morice.

3704. Since 1879 there has been that accumulation?—Yes.

3705. With regard to the mud at the two points that you have been asked about, does not this mud apply to all the points that you have mentioned?—Yes.

Examined by the Commission.

3706. (*Colonel Ewart.*) Did you say that you supplied building sand to a large extent?—Yes.

3707. Then for that purpose you want fresh water sand?—Yes.

3708. Has the cost of the sand been altered by the distance that you have to go to get it?—Yes.

3709. The cost has increased, has it?—Yes.

3710. Then again, do you have any questions raised about the saltness of this sand if it is used for building purposes?—Yes, we do unfortunately.

3711. Has there been any question raised in consequence of your having gone lower down?—Yes; they prefer the salt to the sewage in the sand.

3712. But if you go down to those points below Gravesend, would you not get a larger amount of salt in your sand for building purposes?—Gravesend sand is very free from it in some way; they get it at the last of the tide, and at the tearing down of the upper water you have fresh water coming down. We can only get this sand at ebb tide, and therefore no salt water runs over the Gravesend sand; it is purified by the fresh water running over it.

The witness withdrew.

Captain Michael Williams called in, and examined by Mr. Beaumont Morice.

*Capt. M. Williams.*

3713. I believe you are captain of the "Goliath" dredger?—Yes, I am.

3714. Where?—In Long Reach.

3715. How long have you been there?—Three years. I have not been in Long Reach three years; I have been in Long Reach a year and a half; previously to that I was in Erith Reach.

3716. You have been dredging?—Yes.

3717. What have you been getting up?—Ballast.

3718. What sort of stuff have you been getting up?—We are getting good gravel now; but at times we have found a great deal of soil, particularly just astern or lower down from the training ship "Cornwall."

3719. (*Chairman.*) In Long Reach?—Yes; just astern of the training ship "Cornwall" we have found it from eight inches to a foot thick.

3720. For the last year and a half?—For the last 12 months we have had it.

3721. What were you dredging for?—For gravel for ballast.

3722. When did you first find any mud, as you call it?—Just in the middle of last summer.

3723. (*Mr. Beaumont Morice.*) Whereabouts in Long Reach does the "Cornwall" lie?—Very near to the higher end of it, right opposite Purfleet.

3724. That is the top of the Reach?—That is very near the top of the Reach, opposite the village of Purfleet.

3725. How long did you remain there getting up this soil?—We did not stop long at that, because that is not what we required.

3726. Where did you go to then?—Then we moved farther off to get some better ballast.

3727. (*Chairman.*) Where did you move to?—Farther out in the river, but in the same neighbourhood.

3728. Did you move 100 yards away?—No; perhaps not 100 yards, but very nearly 100 yards.

3729. Fifty yards?—Fifty yards; just as we found it necessary.

3730. You moved about 50 yards away?—Yes.

3731. Did you find it all right there?—We found it better.

3732. Did you find any mud when you moved the 50 yards?—I cannot say rightly now, to be positive.

3733. Did you remain there till the present time?—We shifted to different places.

3734. Why did you shift?—When we shift sometimes it is dirty, and sometimes the gravel has been all taken up.

3735. (*Mr. Beaumont Morice.*) Why did you shift

about so much?—Sometimes when we lowered the ladder down to get ballast, if you understand it, we have frequently just astern of the training ship "Cornwall" found it dirty; that is quite sewage.

3736. Then you went more out into the stream?—Yes, where the current of water is running strong, and that keeps the gravel cleaner, because it washes it.

3737. I understood you to say that you left Erith Reach because of the mud?—Yes, it got so thick that we could not do anything with it. In some parts of Erith Reach, for instance, in the upper part of it near the coal hulk, I should think it is very nearly 2 feet thick, nothing but sewage matter; so that it was not at all profitable work, and sometimes it was very offensive.

3738. In dredging in Long Reach, are you obliged now to go into the strength of the stream?—We are in a great measure, to have it clean.

3739. Since you have been dredging, has there been an increase of this mud and stuff on the banks of the river?—Yes. I have not been many years at it; but in the little time that I have known it there has been an increase.

3740. Is that mud, or is it anything different from mud?—It is sewage matter, I should think; it is very offensive; when it is stirred up you can hardly endure it.

Cross-examined by Mr. Michael.

3741. Will you point out to me on the map behind you where the sewage matter is?—I cannot say that I can see that clearly.

3742. Is it on the Erith side or on the other side?—I think all the way down the Erith side is full of mud.

3743. I understand that you have been three years engaged in dredging?—Yes.

3744. During that time have you noticed the mud increasing in Long Reach?—That is a question that I can hardly answer.

3745. (*Chairman.*) I understood you to say that you had been only a year and a half at Long Reach?—I have been about a year and a half in Long Reach, and about a year and a half in Erith Reach.

3746. (*Mr. Michael.*) You have been for three years engaged in this portion of the river; is that so?—I have been engaged for three years in the river.

3747. Have you been noticing the increase or otherwise of mud in this part of the river between Erith and Long Reach during the last three years?—That is a point upon which one can hardly answer yes or no.

3748. (*Chairman.*) Have you noticed any increase?—I think it is increasing.

3749. Have you noticed it?—I cannot say that I have noticed it.

3750. (*Mr. Michael.*) Then you have not noticed, one way or the other, whether it is increasing or no; is that so?—That is it.

3751. On either side, whether at Purfleet or Erith?—I am quite satisfied that in Erith Reach it greatly increased during the little time that I was there.

3752. Is that in the last 18 months, or in the 18 months before that?—In the 18 months before that.

3753. Then in the 18 months before the last 18 months you noticed that the mud was increasing at Erith?—Yes.

3754. How much ballast do you take up in a boat a week?—I do not think that is the question, if you will excuse me.

3755. That is the question I put to you. How many tons of ballast do you ordinarily take up in a week in a boat?—We take it in barges. I should say that we average about 3000 tons per week; but it varies.

3756. How many boats will be engaged in order to get the 3000 tons?—Some boats will take 20 tons, and others will take 150 tons, so that it is difficult to say.

3757. Are you always engaged in one boat?—I am the captain of the dredger.

(*Mr. Beaumont Morice.*) I do not think it is a question that it is possible for the witness to answer.

3758. (*Mr. Michael to the witness.*) What is the tonnage of the dredger?—I could not say.

3759. What is the horse-power of it?—About 30 horse-power.

3760. How much does the dredger raise in a week?—I told you I should say about 3000 tons, but it varies; it depends upon the customers who come. Sometimes we may have a good many barges.

3761. Is that the dredger in which you are engaged?—Yes.

3762. How many dredgers are there at work getting ballast?—That is not for me to answer.

3763. Do you know or not?—I do not know.

3764. What is the name of your dredger?—"Goliath."

3765. Do you know the names of any others?—Yes, there is one called the "Hercules," belonging to the same corporation that I belong to.

3766. (*Mr. Abernethy.*) 3000 tons is very moderate work for a dredger, is it not?—It is a very good week's work.

3767. (*Chairman.*) Is it necessary to pursue this in detail?

(*Mr. Bidder.*) It is a material point in our case, though I cannot disclose at the moment what the materiality of it is. It is not a question of the credibility of the witness, but we want the fact for a reason of our own.

3768. (*Chairman to the witness.*) Your own dredging vessel is the "Goliath," and it dredges 3000 tons?—I do not know that I should be right to say how much business we do do, but I should say about 2000 to 3000 tons a week.

3769. The question put to you is whether you know the other dredging machines?—Yes, several.

3770. Will you give Mr. Michael the names of those machines?—There is the "Hercules," belonging to the same corporation as I belong to; that is one. Then there is the "Bee," belonging to Mr. Williams. Then there is another, called the "Ant," belonging to the same person. That is all that I could say. I believe the Conservancy have two or three, but where they are employed I could not say.

3771. (*Mr. Michael.*) Those four are employed in Long Reach?—Yes.

3772. Are they of the same power as yours?—I could not say that. I do not know what power they are.

3773. And you cannot tell me about how much they raise per week?—I should think about the same as ours, and perhaps rather over.

Re-examined by Mr. Beaumont Morice.

3774. I understand that you raise the stuff according as customers come for it?—Yes; it is just like a grocer's shop; if many customers come we serve them, and if they do not come we do not sell anything.

3775. Therefore you may raise more one week than another?—Yes, and we very often do. Sometimes we raise 5000 or 6000 tons a week.

Examined by the Commission.

3776. (*Dr. Stevenson.*) You say that you went further out into the river; are you allowed to go as near as you like to the shore when you are dredging?—We are not. We have restrictions as to how near to go to the banks of the river. There are two points lately put up, and at first we had an order to keep 300

*Capt. M. Williams.*

22 Nov. 1882.

feet away, and now we have had an order just issued to keep 900 feet away.

3777. Then you are not allowed to go so near in as you were formerly?—No; that is the place where we want to get.

3778. Had those restrictions anything to do with your going further out into the river?—Yes, partly. At one time we had no restrictions at all.

3779. (*Chairman.*) Who imposes those restrictions? This order is issued from the Conservancy.

3780. (*Dr. Stevenson.*) Do you know why they imposed those restrictions?—They thought we were damaging the embankment.

3781. Has it given way at all?—It has been giving way for all time, from what I can learn. They have been repairing it for many years.

3782. But had it given way during the year and a half that you were working there?—No, not to my knowledge, although they say it has; but we think it has not.

The witness withdrew.

Captain Joseph Richard Whitehorn called in, and examined by Mr. Beaumont Morice.

*Capt. J. R. Whitehorn.*

3783. I believe you are captain of the "Hercules" dredger?—Yes.

3784. How long have you been there?—I have been on board 27 years.

3785. Where is she dredging now?—Between Greenhithe and Purfleet.

3786. For how long have you been dredging there?—For six months past.

3787. That will be in Long Reach?—Yes.

3788. Where were you dredging before that?—In Erith Reach.

3789. How long were you dredging there?—We have been on and off there for about 10 years.

3790. What used you to dredge for?—Gravel.

3791. Why did you leave Erith Reach?—On account of the badness of the stuff, the material coming so bad.

3792. (*Chairman.*) What do you mean by "bad"?—Soft stuff that came up. With a bucket of gravel we should have a quantity of sewage matter, as we term it.

3793. (*Mr. Beaumont Morice.*) Will you tell the Commission how you noticed that there was sewage amongst the gravel?—The lightermen will not take it if there happens to be any bad stuff in it. It must be all clean gravel, because it is for concrete purposes.

3794. (*Chairman.*) You do not know anything about it, but you merely judge from what the lightermen say?—We see it coming up in the buckets, and we take it out of the buckets with a spud and smell it.

3795. You smelt it and saw it?—Yes.

3796. And from your eyes and from your nose could you form any judgment as to what it was?—We attributed it to the sewers, and to nothing else. We never had it before the sewers came there.

3797. You believe it was sewage matter?—I believe it was sewage matter.

3798. (*Mr. Beaumont Morice.*) What was the colour of it?—Very black.

3799. Was it different from mud?—Yes, quite different from mud.

3800. Was there any stench with it?—Yes.

3801. Was it in any particular part of the bucket that it came up; was it mixed with the sand?—It was all mixed with the sand.

3802. Then you had to go from Erith Reach?—Yes, to shift away down till we came to cleaner stuff, to Long Reach, to Purfleet, where a greater rise of tide would keep the ground cleaner. We used to work opposite the sewer at one time in Halfway Reach.

3803. You say that you worked at Erith for 10 years?—Yes, on and off.

3804. It is only six months since you came into Long Reach?—The stuff was so bad that we had to shift.

3805. You worked at Erith for 10 years up to within the last six months?—Yes, and in Half-way Reach as well.

3806. In whose service are you and the last witness?—In the service of the Trinity House.

3807. You have been dredging for 27 years, and therefore you knew the river before the outfalls were opened?—Yes.

3808. Where were you dredging before the outfalls were opened?—Above the sewer in Barking Reach.

3809. What did you get there?—Very clean stuff; it was rather fine sand, but it was very clean. There was no mud with it.

3810. When did you have to go lower than Barking Reach?—About eight years back.

3811. But you have been 10 years in Erith Reach?—We come up and down to try the stuff. We do not always stop in one place.

3812. (*Chairman.*) The question is, when did you leave Barking Reach for good?—Perhaps 12 or 14 years ago; but we have worked up and down, and kept shifting about during the time that I have been on board the vessel.

3813. (*Mr. Beaumont Morice.*) Then you were working in Erith Reach, and I suppose down Erith Rands, for about 10 years?—I daresay I was.

3814. In what part of Long Reach particularly are you working now?—On the south shore, about halfway down, off Little Powder-monkey Creek.

3815. Have you any difficulty in getting sand there now?—No, we have got a bit of ground there now.

3816. How far up the river can you go to get gravel at the present time?—I do not think we should find anything above Erith, not to say good clean gravel now.

3817. (*Mr. Bidder.*) Have you tried?—Yes.

3818. (*Mr. Beaumont Morice.*) You have been trying, I understand, for 27 years altogether?—Yes, on and off.

3819. (*Chairman.*) When did you try for the last time up in the direction which the learned counsel is asking about?—Between two and three years ago, as well as I can recollect.

3820. Where did you try then?—At Dagenham.

3821. With what result?—It was no good at all. It was all mud and sewage with it, and we had to leave it and go away again.

3822. Was it like ordinary mud, or what was it like?—It was very soft stuff, and not exactly like the mud you would see in the streets; it is of a bluish cast, and very soft, and it does not smell very nice either. It is a different kind of mud from what you see on the shore.

3823. What do you mean by its not smelling very nice?—In the summer time we worked off the sewer, and we smelt the stuff.

3824. When you say that it did not smell very nice, do you mean that it smelt like sewage?—Yes.

3825. (*Mr. Beaumont Morice.*) Will you give us in your own words what sort of a stench it was that this stuff smelt like?—On a summer's morning I have been on deck and I have had to go below when the sewage matter has been coming out from the sewer; and it has been quite as black as ink, with a faint smell.

3826. Has there been anything of a similar smell about the muck that you got up with the sand?—Yes, it is similar; you can tell it directly. We have had so much of it that we know what it is.

3827. You have no doubt about it?—I am sure of it.

Cross-examined by Mr. Bidder.

*Capt. J. R. Whitehorn.*

22 Nov. 1882.

3828. As I understand, the times when you have smelt it badly and have had to go below have been when you have been moored opposite the outfall?—Yes, or at Barking; anywhere near there.

3829. You do not cruise about very much with your dredger; you are usually moored somewhere?—Yes.

3830. And when you were dredging at Dagenham you were just opposite the outfall?—Yes.

3831. When the sewage was discharging close to you it smelt strong and faint?—Yes; it was high water, and we were not dredging at the time.

3832. I did not say you were. Do you go and dredge wherever you like?—No.

3833. Who settles where you are to go and dredge?—The Thames Conservancy.

3834. You were mainly in Half-way Reach for 10 years?—Yes, there and in Erith Reach combined.

3835. You could not be in two places at once. You were working in Half-way Reach, you told us, for 10 years and then you went to Erith Reach?—Yes.

3836. During those 10 years, I presume that you dredged a very large quantity of stuff in Half-way Reach?—Yes.

3837. What is the capacity of your dredger?—We average 2000 tons per week at the present time.

3838. Is it not the fact that where you were dredging in Half-way Reach was at a place called Dagenham Shoal?—Yes.

3839. And that, until about 15 or 16 years ago, or more, was a shoal that contracted the channel and the depth of the river?—Yes, it would do so.

3840. And I think the Conservators cut off the hard cap of the shoal that prevented the ordinary dredger being able to touch it?—Yes.

3841. And after they had done that the dredgers set to work?—Yes, so they did.

3842. Were there other dredgers at work at it besides the "Hercules"?—Yes, the "Thorpe," the "Sampson," and the "Goliath." They were all work-in the reach at that time.

3843. And they were all engaged for the best part of that time on that shoal?—No; the "Thorpe" was not there very long.

3844. But the other three were there steadily?—Yes; not in one spot, but in the reach.

3845. At the end of the 10 years, where there had been a shoal you had dredged a very deep hole, had you not?—Yes, of course we had.

3846. How much deeper did you make that part of the river than it was when you began?—We would make it something like 28 or 29 feet deep.

3847. Do you mean 28 or 29 feet at low water?—Yes.

3848. What was the depth of it when you began?—About 22 feet to 24 feet more or less.

3849. It was not so much as that on the shoal, was it?—Not on the top of the shoal, but the Conservancy moved that away.

3850. The depth of water over the shoal was not above 13 or 14 feet, if I recollect rightly?—It was more than that; it was about 16 feet.

3851. And then on each side it shelved down, and your dredgers cleared away the whole of this, and got a depth of 28 or 29 feet, and then the mud began to collect?—It would not have done so if the sewer had not been there.

3852. And then the mud began to deposit?—It naturally filled in.

3853. Now then I will take you down to Erith; were you employed at Erith also, at a place called Erith Rands?—Yes.

3854. Is that a shoal that used to exist off the point on the north side of the river, opposite Erith Bight?—Yes, there was a shoal there called the Rands.

3855. (*Mr. Beaumont Morice.*) That is below Erith though?—Yes, it is below.

3856. (*Mr. Bidder.*) Perhaps I have got the wrong name, but there was a shoal opposite Erith Bight at Coldharbour Point?—I do not know of one there, only Erith Rands; not to say a shoal.

3857. Will you put your finger upon the place where you mainly dredged at Erith?—There (*pointing it out*).

3858. There was a shoal there, was there not?—Not that I know of. We never saw much of a shoal in Erith Reach.

3859. (*Chairman.*) But you dredged there for a number of years?—Yes.

(*Mr. Bidder.*) Being a marine captain you understand a chart; look at the Admiralty chart (*handing a chart to the witness*). Do you mean to say that you did not know that there was a shoal at that place on the Admiralty Chart?

(*Mr. Beaumont Morice.*) There is a little spit running out; that is what my learned friend means, I think.

3860. (*Mr. Bidder.*) I prefer to call it a shoal. (*To the witness.*) Calling it whatever you please, there was a place there where the bed of the river was shallower than the rest of it?—In places all over the river.

3861. But I mean in this particular place where you dredged; and you dredged that entirely away, did you not?—Yes, we should take it away as we came to it.

3862. You did take it all away?—I cannot say that we took it all away. If the stuff was not good we should not take it.

3863. (*Chairman.*) You did take away a quantity of stuff?—I cannot say that we took it all away; we may have left some.

3864. But you did take away a great quantity of material from that place?—Yes, we have done so.

3865. How long were you dredging round that place?—We would go a certain distance, and come back again. We were dredging there for 8 or 10 years, as far as I can guess.

3866. Then for 8 or 10 years you were dredging all round that point?—Yes.

3867. (*Mr. Bidder.*) That was at Dagenham, was it not?—All the way down, because we work down a reach and then go up again.

3868. (*Chairman.*) I asked you how long you were dredging upon the portion that you pointed out to the learned counsel?—About 8 or 10 years. I have been 27 years on the ship between Woolwich and Erith. We do not stop in one place.

3869. (*Mr. Bidder.*) Will you point to the different places in that reach down to Erith where the water was shoal?—Where the gravel was clean; we go wherever we find the stuff clean; we do not go for shoals.

3870. At Erith was the result of your dredging to greatly deepen and widen the channel on the north side of the river?—We did do so unquestionably.

3871. And all the way up on the north side as far as Dagenham?—Yes, on account of the gravel being cleaner on that side.

3872. (*Chairman.*) I suppose we shall get this accurately from a comparison of the charts?

3873. (*Mr. Bidder.*) At the proper time we will give it you. (*To the witness.*) You work for the Conservators, do you not?—No, for the Corporation of the Trinity House.

(*Mr. Beaumont Morice.*) I am informed that as a matter of fact the Conservators do not tell the Trinity dredgers where to go.

3874. (*Mr. Bidder to the witness.*) You said just now that the Conservators tell you where to go?—If we get too near the shore they find fault with us. We are under the jurisdiction of the harbour-master.

(*Mr. Lumley Smith.*) If they get too close to the shore they are warned off.

3875. (*Chairman to the witness.*) You are an officer of the Trinity House, and if you encroach upon the domain of the Conservancy, the Conservancy and their employés will warn you off?—Yes.

*Capt. J. B. Whitehorn.*

22 Nov. 1882.

(*Mr. Bidder.*) The whole river is the domain of the Conservators in the same sense.

(*Mr. Lumley Smith.*) These dredgers are the servants of the Trinity House, and they are allowed to go where they like to get ballast for their own profit. If they get too near the banks in places where they will do harm they are warned off either by the Trinity House or by the Conservators; but they are not ordered to go to any particular place.

(*Mr. Beaumont Morice.*) And they go for the purpose of getting ballast, and not for the purpose of dredging.

3876. (*Mr. Bidder.*) It is the first time that I ever heard that the business of the Trinity House was to sell ballast; I thought that they had a deep interest in the navigation of the river. (*To the witness.*) After that, as I understand, recently you went to Long Reach?—Yes.

3877. In order to get a better quality of gravel?—Yes.

3878. And there you got what you wanted?—Yes, and we get it at the present time.

3879. It is quite different from the sewage mixed stuff that has been spoken of higher up?—Yes.

3880. Do you mean that it is sharp and clean?—Yes; there is clean red gravel there at the present time.

3881. If you go to Half-way Reach, or to Erith, then you get a nasty soft mud, and if you go into Long Reach you get a clean red gravel or sand, I suppose?—Yes, there is some sand with it.

Examined by the Commission.

3882. (*Mr. Abernethy.*) Can you find that gravel in all parts of Long Reach?—No, not in all parts. It is deep water in the centre of the reach; there is very good gravel on the south shore, and very good on the north shore. We are not allowed to work in the channel on account of the large ships that come up and down; the harbour-master orders us to one side or the other.

3883. Do you find red gravel all over that reach?—We are not allowed to go all over it.

3884. (*Chairman.*) But in all such parts as you have been over you have found nothing but clean gravel?—Yes, clean gravel.

3885. As high up as Purfleet?—Yes.

3886. Do you know the mud up there?—No; I have been down with the staff below Purfleet, and found nothing but soft sewage matter and mud.

3887. But that is in Long Reach?—At the bottom of Long Reach, on the north shore.

3888. You find mud there?—Yes, on the shore.

3889. (*Mr. Abernethy.*) You told Mr. Bidder that you found nothing there but shoal?—Not with the dredger. The shore in the river is not so clean as it used to be. I do not say with the dredger because we cannot go on the shore.

3890. (*Chairman.*) Have you found any of this offensive matter in Long Reach?—No, not at present.

3891. You tell us that you get up beautiful red sand and gravel by dredging; but I ask you whether below Purfleet you find any of this dirty stuff that you have been speaking about?—We have not done so yet with the dredger.

3892. I am not asking you about the dredger, but as an experienced man, and knowing that part of the river, will you tell me where you have found any of that dirty stuff?—Where there is an eddy-tide there seems a settlement of mud.

3893. Whereabouts?—On the north shore away down to what they call Sun Point.

3894. Below Purfleet?—Yes, right down to the point. I see it on the shore.

The witness withdrew.

Captain Walter Shepherd called in, and examined by Mr. Beaumont Morice.

*Capt. W. Shepherd.*

3895. I believe you are the captain of the steam tug "Wildfire," belonging to the East and West India Dock Company?—Yes.

3896. How long have you known the River Thames?—Over 40 years.

3897. Do you remember the outfalls being opened?—I recollect their being opened, but I could not tell you what year it was in.

3898. Could you tell us if there has been any alteration in the river since the outfalls were opened?—The river has been in a very bad state.

3899. What do you mean by being in a bad state?—It smells very badly. There is a lot of refuse swimming about. I should suppose it was refuse from a sewer.

3900. Is there a smell to it?—Yes, a very bad smell, an odious smell.

3901. What kind of smell is it?—I can hardly tell you; it is a regular stink.

3902. (*Chairman.*) A stink of what kind?—Of sewage.

3903. (*Mr. Beaumont Morice.*) Has there been any increase of that during the last few years?—It was worse two years ago than it is now. We had hot weather in the summer months, and that caused it to be much worse.

3904. This summer it has been cooler?—Yes, it was cooler this summer.

3905. Can you tell us, from your knowledge of the river, how far sewage would go down the river on an ebb tide?—I should not think it would go further than the Lower Hope, the lower part of the Hope.

3906. Can you tell us how far it would go back on the flood?—I should not think it would reach much farther than Crossness. You mean from the Hope up.

3907. It would go as far as the Lower Hope, and then it would meet the flood?—Yes.

3908. Is the flood tide as strong as, or stronger than, the ebb?—The ebb tide is the strongest.

3909. Which will run for the longest time?—The ebb tide runs the longest.

3910. Can you tell the Commission how far you think it will come back on the flood?—To Crossness, or further.

3911. Why do you say that the ebb tide is the strongest?—The longest, I understood you.

3912. Is that so or not?—The spring tides are the strongest on the flood.

3913. But, taking the tides ordinarily, which tide is the strongest, and which would run the longest?—The ebb tide runs down seven hours, and the flood tide runs up five hours.

(*Chairman.*) There is all the difference between the spring tides and the neap tides, I suspect.

(*Mr. Bidder.*) Of course the ebb tide has to take down the fresh water as well as the salt water that comes up.

3914. (*Mr. Beaumont Morice to the witness.*) Have you ever ascertained how far anything starting on the flood would come back up the river?—That would all depend upon the weather.

3915. (*Chairman.*) Have you yourself noticed how far a thing would go up?—No, I have never noticed that.

3916. (*Mr. Beaumont Morice.*) Have you ever suffered any ill effects from this sewage?—Not any, any more than that I have felt a little bit queer, when I have called at Crossness, from smelling the odour. I have felt a sickness.

3917. You know the state of the mud, do you not, on the banks up and down the river?—Yes.

3918. Can you tell the Commission what that is like?—It is black and greasy.

3919. Is there any smell to it?—Yes, a very bad smell.

3920. What kind of smell?—It smells like sewage.

3921. Has there been, to your knowledge and observation, any increase of that deposit of mud or sewage in recent years?—There is not so much water in Halfway Reach as there was before the sewerage.

3922. Is that the case, not only in Halfway Reach, but in other reaches?—In the other reaches; but I can speak more of Halfway Reach, because I tried there, and I know by that.

3923. Do you know the lower reaches around Erith Bight?—Yes.

3924. Can you tell me whether there has been any increase there?—I could not say, because I do not travel so far down as that.

3925. But you say that where you have seen it, the increase is of this sewage type?—Yes, because I have picked it up on my anchor when I have had occasion to let go my anchor.

3926. And, therefore, you have no doubt about its being sewage?—No; you have to handle it then.

3927. Have you ever noticed any lumps floating about in the sewage?—Yes, any amount of them, balls of sewage.

3928. Have you seen them often?—Yes, very often; but not lately.

3929. When was the last time you noticed them?—I think I saw one on Monday, but previously to that I had not seen any for a long time, say a twelvemonth or more.

3930. Have you ever noticed any dead fish in the river, and on the banks of the river?—Yes; eels.

3931. When did you last see that?—About a fortnight ago. They were not on the banks of the river, but floating in the river, dead.

3932. Have you often noticed that before?—Yes, at times of the year.

3933. At this time of the year generally?—I believe these eels come down with the land water, and they get smothered down there at Crossness, and then you see them floating dead after that.

3934. Have you ever been down with barges drifting down the river?—Yes.

3935. On an ebb tide?—I have generally worked the short distances. I have been more used to sailing and steam boats, and tugging.

Examined by Mr. Lumley Smith.

3936. You have not, as I understand, made any observations or experiments to see whether the tide is stronger on the ebb or on the flood.

*Mr. Bidder objected to the question.*

*The Chairman ruled that the question might be put.*

3937. (*Mr. Lumley Smith to the witness.*) When you speak about the ebb tide being longer or stronger in its operation than the flood, have you made any observations at all for the purpose of seeing whether that is so or not?—No.

Cross-examined by Mr. Michael.

3938. You are, I think, the captain of the "Wildfire"?—Yes.

3939. Are you engaged every day in towing down barges to a point in the river near Erith?—Yes.

3940. How many barges do you tow down?—Five.

3941. Once a day?—Once a day.

3942. Do any of your men live in a hulk on the river itself?—Yes.

3943. That is moored, I think, close to Crossness?—Yes.

3944. How many men live there?—There are three stationed there, but they are not all there at one time.

3945. They live there and sleep there, do they not?—Yes, in their turns.

3946. How many men do you employ altogether?—There are five lightermen, and those three men down there.

3947. Do the lightermen take their turns with the three other men?—No; we go away with the steamboat to Erith, and are only too glad to get out of it.

3948. How long do those three men who are in this hulk stay at a time?—Perhaps an ebb tide. Then they moor their craft on the next flood, and then the other men take their turn.

3949. Where is it that you have noticed the smell from the water that you speak of?—When I turn the vessel round at Crossness.

3950. And how far does it extend?—When we turn round we are only too glad to get out of it; we do not stop to see how far it extends; but at Erith we have found plenty of refuse from the sewers, and we can smell it there.

3951. At what time of the year is this?—It is at all times of the year. It has not been so bad these last six or eight months as it was previously.

3952. And that is the only place where you have the smell from the water?—No, we have it coming up the river; up as far as Blackwall I have smelt it.

3953. The water itself?—The water itself.

3954. At what time of the year?—I daresay it was 12 months ago when I first saw it there.

3955. But I am speaking of the smell that you say arises from the water?—You get so used to the smell, because you are smelling it all up the river so far as it goes.

3956. How far up?—As far as Blackwall; as far as I go.

3957. Then all the time, and at all periods of the year, you smell the water as you go through it?—Yes; and sometimes it is worse than at others.

3958. (*Chairman.*) But you can smell it at all times as far as Blackwall?—You can smell it at all times as far as Blackwall, and you can see refuse.

Re-examined by Mr. Beaumont Morice.

3959. I understood you to say that you make short trips?—Yes.

3960. And you have not been in the habit of going up and down the whole length of the tide?—No.

3961. Therefore you cannot speak with any certainty with regard to how far the tide will extend, one way or the other?—No, I cannot.

3962. I understand you to say that the smell is not confined to Crossness, but that you smell it all up and down the river?—Yes.

3963. And that even when you go out of it to Erith, you find it bad enough there?—Yes.

The witness withdrew.

Mr. Augustus Robert Edmunds called in, and examined by Mr. Beaumont Morice.

*Mr. A. R. Edmunds.*

3964. What are you?—I am a barge builder.

3965. And you live at Blackheath, I think?—Yes.

3966. How long have you known the River Thames?—All my life.

3967. (*Chairman.*) Shall we say 50 years?—Yes.

3968. (*Mr. Beaumont Morice.*) Do you remember the outfalls being opened?—Yes.

3969. Has there been any difference in the state of

*Mr. A. R. Edmunds.*

22 Nov. 1882.

the river from the time that the outfalls were opened?—Yes.

3970. In what way?—The upper reaches of the river, that is to say, from London Bridge to Limehouse, have become purer, and the lower reaches have become more foul year by year.

3971. What do you mean by saying that they have become more foul?—The water has been thicker, and the smell has increased.

3972. (*Chairman.*) In sweetness?—No. There was always a bad smell in the upper reaches before the cholera; and that same kind of smell is now in the lower reaches.

3973. (*Mr. Beaumont Morice.*) What was the smell like?—It is a closet smell, but weaker, and more sickening.

3974. Has that been increasing year by year?—In the lower reaches.

3975. Have you ever felt any ill effects from that?—In the summer time almost every morning; in fact every morning.

3976. In what way does it affect you?—I leave home quite well (my works are in the marshes down at Point Wharf, East Greenwich), and as soon as I get to the steamboat pier at Greenwich I feel unwell. Then I am on the river almost all day; my counting-house is almost on the water.

3977. In what way do you feel the effects of it?—In the summer I have my breakfast at Blackheath at 8 a.m., and sometimes I am not able to eat again until 5 or 6 in the evening; and that happens for weeks together.

3978. (*Chairman.*) Then it is loss of appetite that you suffer from?—Loss of appetite and faintness. Of course from want of food I am faint.

3979. Do you know the state of the mud on the banks of the river about Blackwall, or below there?—Just round the point in Bugsby's Reach I know it well; I pass it every day.

3980. That is the reach below Blackwall, is it not?—Yes, below Blackwall Reach; the next reach to Blackwall Reach is Bugsby's Reach. My works are at Blackwall point, East Greenwich.

3981. Do you go there?—Yes; there are my works (*pointing them out*). Every day I come there, and every day I cross Bugsby's Reach to go on the other side of the river.

3982. Can you tell us the state of the mud on the banks of the river up to the point you go to?—It is brown on the top and black as ink underneath.

3983. Is it mud?—Yes, it is thick mud and very stinking.

3984. Is there any particular smell to it?—A very bad smell indeed. As I row past it every day in the summer time it is exceedingly offensive.

3985. (*Chairman.*) What kind of smell?—Precisely the kind that I have described, a closet smell, but fainter. That is the nearest description of it I can give.

3986. (*Mr. Beaumont Morice.*) Have you noticed that at more than one part of the river?—Yes, at Cubitt Town my nephew has a place, and it is very black there.

3987. I believe you pass several of the steamboat piers during the day?—Yes, continually.

3988. Do you notice it there at all at the different piers?—There is the same description of mud at almost every pier, but it is better as you go higher.

3989. Have you ever had any persons in your employ who have suffered illness from this?—Yes, 30 years ago.

3990. Within the last few years have you had any sickness amongst your men?—No, I have not had any sickness amongst my men, not sickness unto death; none of them have died.

3991. (*Chairman.*) Have you had any sickness amongst your men during the last few years?—No.

3992. (*Mr. Beaumont Morice.*) You go down the river in a steamer very often, do you not?—Yes.

3993. Have you noticed the water of the river that is stirred up by the steamers?—Yes.

3994. What is that like?—It is of the same smell and the same colour as I have described.

3995. (*Chairman.*) Is this between Greenwich and Blackwall?—Right away up to Limehouse.

3996. (*Mr. Beaumont Morice.*) Have you ever gone further down the river than you have been telling us about?—Yes, continually.

3997. How far have you gone down the river?—To Gravesend.

3998. Have you ever noticed anything of this kind with regard to the mud or the smell that you have been mentioning lower down the river?—It is bad right away from Blackwall to Gravesend.

3999. (*Mr. Bidder.*) The smell, or the mud, or the water?—The smell, and the mud, and the water.

4000. (*Mr. Beaumont Morice.*) Are there any parts where you have specially noticed it?—Especially where the sewage outfalls are, at Crossness and Barking, and right away to Gravesend, and especially at Gravesend, as I have sat there.

4001. Could you tell, from your experience on the river, how far anything would be taken down on an ebb tide?—Yes.

4002. (*Mr. Bidder.*) Have you made observations?—Yes; when I was young I served my time as a lighterman, and I know exactly how far a barge will drift on the tide.

4003. (*Mr. Beaumont Morice.*) Speaking from your experience, how far would a barge drift on an ebb tide starting from a given point?—It would drift from Crossness to Gravesend on an ebb tide, but not further.

4004. You have actually noticed that?—Yes, I have rowed a barge down.

4005. (*Chairman.*) Then that is more than drifting?—Scarcely more, because you lay the barge athwart, and it drives.

4006. (*Mr. Beaumont Morice.*) If you got as far down as Gravesend on the ebb, and then started back on the flood, how far back would you be likely to drift?—The barge would drift almost as far back, I should think.

4007. (*Chairman.*) Have you tried?—Yes, I have brought a barge back from Gravesend in one tide. A barge would come back as far, and I conclude that the sewage would come back as far too.

4008. But you have tried a barge, and a barge has come back as far as from Gravesend to Crossness?—Yes.

4009. You have drifted down in a barge from Crossness to Gravesend on the ebb tide?—Yes.

4010. And then on the flood tide you have come back from Gravesend almost as far as Crossness?—Yes.

4011. (*Mr. Beaumont Morice.*) Have you ever noticed any lumps floating in the water?—My men have picked them up. I have not noticed them myself.

4012. Have you ever noticed anything on the top of the water, any grease, or anything of that kind?—Continually, slime.

4013. Has there been any increase of that lately, in the last few years?—There is an increase of it every year.

Cross-examined by Mr. Bidder.

4014. How often do you go down the river below Blackwall to Gravesend or Barking?—Formerly?

4015. Now, I mean?—Four or five times during the summer.

4016. For amusement, or on business?—For business and amusement.

4017. When you tell the Commissioners that the lower reaches are worse, you mean from Limehouse, how far?—Right away to Gravesend.

4018. About Limehouse you say it is better?—Above Limehouse I know it is better.

4019. This smell that you speak of, I understand, you notice everywhere every day?—In the summer time every day.

4020. And the mud; is that confined to the summer, or is it always so?—It is not always so; it is confined to the summer mostly.

4021. I do not know whether you can charge your memory with the appearance of the mud in the river 20 years ago; do you recollect what the mud used to be like?—I can remember it 30 years ago.

4022. Did you ever see mud at that time which was brown above and black beneath?—Yes, in the upper reaches at Limehouse, and near London Bridge at Fresh Wharf.

4023. And lower down too?—Lower down not so much.

4024. Still it was to be found?—Yes, but rather of a more yellow quality; not so black.

4025. But the yellow is above and the black is below?—Yes.

4026. You do not suggest that this brown at the top is a coating of something different from the rest of it?—I should think that it was made brown by the action of the atmosphere on it, but I am not chemist sufficient to tell you the reason for it. It might be a kind of oxygenizing.

Re-examined by Mr. Beaumont Morice.

4027. In fact, 30 years ago the upper reaches were worse, and the lower reaches were better, than they are now?—Yes.

4028. And now the matter is just changed?—Yes, that is so.

The witness withdrew.

Mr. George Saunders called in, and examined by Mr. Beaumont Morice.



4029. I believe you live at Erith, and you are foreman to Messrs. Beadel Brothers?—Yes.

4030. Have you lived near the Thames or about 21 years?—Yes, I have lived there 21 years.

4031. How have you been engaged during that time?—I have been engaged under Mr. Beadel in that time, and I have been foreman for him for about 16 years.

4032. But what have been your duties during the time?—Working on the wharf and about the wharf.

4033. Then you have been alongside the river mostly?—Yes.

4034. Do you remember the river before the outfalls were opened?—Yes.

4035. Can you tell us if there is any difference between then and now?—Yes, there is a great difference.

4036. In what way?—The water is much thicker, and there is dirty stuff in it now, and a great accumulation of sewage stuff in the berths where the ships come, and we have great difficulty in keeping them clean.

4037. Accumulation of what?—Accumulation of mud—sewage stuff.

4038. How can you tell that it is sewage stuff?—Because it smells so strong.

4039. What kind of smell is it?—A nasty sort of smell, something like what comes out of sewerage.

4040. Have you ever had any barges or vessels sunk in the river off there?—Yes, we have.

4041. How long ago?—We had one sunk about two years ago.

4042. When she was raised, in what state was she?—In a fearful state.

4043. (*Chairman.*) What do you mean by a "fearful state"; what was the condition of the barge when she was raised?—There was a kind of sewage mud in the barge when she was raised.

4044. Have any of your men been ill owing to this?—Yes, I have had several of them laid up these last two or three years.

4045. (*Mr. Beaumont Morice.*) Do those men work at discharging the ships?—Yes.

4046. Has that happened more of late years than it used?—Yes, more lately, because I have got a club on the wharf to which they pay 6*d.* a week, and I used to be able to keep that up, and now I cannot; so Mr. Beadel helps me a little to keep on with it.

4047. Has there been more illness amongst your men of late years than there used to be?—Yes, there has.

4048. Have you much mud up above Erith?—I do not know much about above Erith.

4049. Do you have more mud now in the berths where the ships are than there used to be?—Yes, a great deal more, because we only used to have one man in occasionally, and now I am obliged to have one regularly, and sometimes three, and sometimes more, to keep the berths clear.

4050. What sort of stuff is that mud?—It is a kind of sewage, black mud.

4051. How long was this vessel that was raised under water?—She was under water for about two days, I think.

4052. (*Professor Williamson.*) What do you suppose was the cause of the illness of your men?—I can hardly say.

4053. You have no reason to attribute it to any one thing?—No, to no one thing in particular.

Cross-examined by Mr. Bidder.

4054. These men actually work in the mud, clearing the channel, do they not?—I have got three doing that.

4055. Were any of those men laid up this year?—Yes; I have got some of them laid up at the present time.

4056. How many of them?—I have got three laid up now.

4057. Is a doctor attending them?—Yes.

4058. We will hope that he knows what is the matter with them?—I daresay he does.

4059. What is the name of the doctor?—Jesset is the doctor's name.

4060. Do you suggest that they are all laid up on account of the smell of the river?—I cannot say.

4061. I suppose you have had this sick club for many years?—Yes, I have had it for 14 years.

4062. And you have had men from time to time laid up, and upon it?—Not at all times; sometimes we are pretty free; but they have been worse lately.

4063. Lately you have had more occasion to have men working in the mud than you used, have you not?—Yes.

4064. And in the water too, I suppose, because they have to get wet working in this mud?—No, the tide leaves the berths altogether.

4065. They go in in long boots, do they not?—In long boots.

4066. You say that there is more mud than there used to be on your side of the river?—There is.

4067. You call it sewage stuff; may I assume, that like other witnesses, your reason for that is simply because it looks nasty and smells nasty?—Yes, that is it.

4068. You have not analysed it, I suppose?—I have not; but it smells very strong in the summer time.

4069. By-the-by, when you talk about the mud smelling strong, do you happen to have the Erith sewer discharging at your wharf on to the mud right under your nose?—No; there is a sewage place just below there; but I do not think it is from that, I could not say. There are some pipes laid down just below the wharf.

4070. Are they sewage pipes?—I believe so.

4071. Is the Erith sewage discharged through them?—Yes.

4072. On to the mud in front of your wharf?—No, not in front; a good bit below the wharf.

4073. How much below the wharf?—Well, I could not say. I have not measured it.

4074. (*Mr. Abernethy.*) Do you mean to say that

*Mr. G. Saunders.*

22 Nov. 1882.

all the sewage of Erith is discharged through those pipes?—No, not half of it, I believe.

4075. (*Mr. Bidder.*) A considerable portion of it is discharged through them, is it not?—Yes, I believe so; but I could not say how much.

4076. Is it about 100 feet from your wharf?—It is further than that; it is nearer 100 yards, I should think.

4077. We can have it measured afterwards. Of course that is washed up with the flood and down with the ebb, I suppose?—Yes, I suppose so. I have never been down to the place.

4078. Would you say that that Erith sewage does not smell?—I could not say. I have not been down to the end of the pipes.

4079. You have never been conscious of any smell from it?—No.

4080. Do you happen to know the other Erith sewer (because we had some doubt about it in the case of the previous witness) which discharges at that causeway?—I have never seen one there.

4081. (*Mr. Abernethy.*) What is the size of the pipe?—It is about a 6-inch pipe, I think.

4082. (*Mr. Bidder.*) Is it not a good deal more than 6 inches? It is suggested to me that it is 15 inches. Will you undertake to say that it is not more than 6 inches?—I could not say.

4083. I have a reason for asking, because I am told that it is larger?—I will not undertake to say.

(*Mr. Beaumont Morice.*) I propose to have the surveyor here next time; and I do not propose to ask this witness any question on the point because, of course, he knows nothing about it.

The witness withdrew.

Mr. Thomas Marshall called in, and examined by Mr. Beaumont Morice.

*Mr. T. Marshall.*

4084. What are you?—By trade a wheelwright.

4085. You live at Erith, do you not?—Yes.

4086. And I believe you are also the sexton of Erith?—I held that appointment.

4087. How long have you been at Erith?—17 years.

4088. (*Chairman.*) How long have you been sexton?—About 14 years.

4089. (*Mr. Beaumont Morice.*) I believe you had to do with a great many of the bodies from the "Princess Alice" disaster?—Somewhere about 30, I think; it might have been 32 or 33, I suppose.

4090. (*Mr. Bidder.*) You buried them, I suppose?—No.

4091. (*Mr. Beaumont Morice.*) When did you first have to do with them?—The first I had to do with drowned bodies, generally, was some 14 years ago.

4092. You had to do with some of the bodies of the "Princess Alice"?—Yes, with about 30, I think.

4093. When did you first have to do with them?—Some of them were brought ashore the very night of the accident.

4094. (*Chairman.*) You received some of the bodies on the night of the accident?—Yes.

4095. How many bodies did you receive?—I think on the night of the accident we received about 10.

4096. (*Mr. Beaumont Morice.*) Can you tell us what time of night it was?—They commenced coming very shortly after the accident; I think about two or three came in the very first boat that was brought ashore.

4097. But what time of the day was it?—At about 9 o'clock at night, I take it.

4098. In what condition were those 10 bodies?—In a very dirty condition.

4099. Will you explain what you mean by saying that they were very dirty?—The pockets of the men and the clothing of the women were one mass of mud, filth of some kind.

4100. What kind of mud or filth was it?—It looked like sewage; and I take it that it was sewage by the smell.

4101. When did you receive any more bodies from the "Princess Alice"?—We received them the next day and the following days for something like a week.

4102. In what condition were those that you got the next day?—They were in a very much worse state.

4103. What do you mean by "very much worse"?—The bodies smelt very much worse.

4104. (*Chairman.*) Not the clothing?—The clothing or the bodies, I could hardly distinguish which. There was a very much worse smell the longer they were in the water.

4105. (*Mr. Beaumont Morice.*) What kind of smell was it?—I could hardly describe it; it was a very horrible smell, almost as bad as a bad privy.

4106. Were they in a different condition from those that you had out of the water 14 years ago?—Yes.

4107. You stated that you had bodies out of the water 14 years ago; where did you receive them from?—From all parts of the Thames within the district of Erith; from just the other side of Crossness where it joins Plumstead, to Crayfordness.

4108. What do you mean when you say that they were in a better condition?—They were not so foul not so full of muck and mess as they are now.

4109. Have you received bodies taken from other waters except the Thames?—Yes, I have had three bodies out of the spring ditches, out of the marshes, and in different parts of the parish of Erith.

4110. In what condition were they?—There was nothing the matter with them; no more than you would see in an ordinary corpse.

4111. None of the sewage that you mention?—Oh dear no!

Cross-examined by Mr. Bidder.

4112. I suppose that if a body falls into clean water and it is got out again, you find the clothes, though wet, to be moderately clean?—Certainly.

4113. But if it falls into mud you find the clothes dirty and muddy?—Yes.

4114. And if the mud happens to be mud that smells badly, the body and the clothes smell badly?—Naturally.

The witness withdrew.

Adjourned to Tuesday next at half-past 12 o'clock.

# EIGHTH DAY.

## Tuesday, 28th November 1882.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary*.

28 Nov. 1882.

(*Mr. Beaumont Morice.*) Perhaps it might be convenient if I now mentioned to the Commission that I have considered the suggestion which they threw out at their last sitting with regard to the class of evidence that I have been tendering to them. I have carefully considered the bulk of the evidence which has been laid before me and which still remains to be tendered, and I think it is only right to inform the Commission that, although there is a number of persons in different ranks of life who would be prepared to give evidence with respect to this matter, yet my case is that there is a widespread feeling of a particular kind. The evidence which I have called, more of which is still in reserve, undoubtedly goes pretty much to the same point, viz., that the pollution of the river is a nuisance and has been caused by this sewage. But beyond this, and beyond the class of evidence, mainly of persons who have spent their lives upon the water, or on the banks of the river, and who are therefore, I submit, well able to speak, from the actual experience which they have had upon this matter, so far as any scientific analysis is concerned, I am not prepared to go. The Commission will bear in mind that it is a matter of great expense to the various parties concerned, in any case, but especially so to the memorialists whom I represent here. Therefore they, having been instrumental in obtaining the appointment of the Commission upon the representations to which I have referred, have thought it right to bring forward a mass of evidence for the purpose of placing it before you. But inasmuch as I have already called before you a number of witnesses who have given more or less the same kind of evidence, without desiring to close my case, or to be thought to close my case, relying upon the evidence of those whom I have already called, I would wish to put before the Commission that there are in reserve a large number of witnesses who have already been tendered to me, but who, I am bound to say, will to a great extent say the same thing as has already been given in evidence here on previous occasions. That being so, I have to-day directed to have brought here the surveyor whom the Commission intimated their wish to examine with regard to the drainage of Erith. I have also summoned Dr. Jessett, who is the medical officer of Erith, to speak with regard to some matters which the Commission wished to know about; and further, witnesses, more or less drawn from different parts of the river, who will be quite sufficient to occupy the rest of this sitting. But having mentioned that, I should be glad if the Commission would make some intimation to me with regard to the remaining evidence, which, on my own responsibility, I am hardly in a position to say that I am not prepared to call; because it is the case of the memorialists, who have been put to considerable expense in this matter, that the nature and character of this nuisance is widespread; and that is the matter which they chiefly wish to lay before the Commission.

(*Mr. Bidder.*) In fairness to my learned friend I ought to point out this: I can readily believe that, as we have already had a considerable number of witnesses who complain of things which they think, and no doubt sincerely think, are attributable to the outfalls, so probably there are a considerable number more who will come and do the same; but it must be distinctly understood that at the proper time, so far from admitting that the nuisance is attributable to the sewage outfalls, I shall be prepared with evidence of various descriptions, scientific and otherwise, to satisfy the Commission that my learned friend's clients are under a misapprehension as to the cause of that which they complain of.

*The Commission deliberated.*

(*Chairman.*) You have produced a large number of witnesses, Mr. Morice, and we have no doubt that you could produce a large number more, to prove the fact that where the sewage falls into the river, lower down, and perhaps even further up, a good deal of unpleasantness is felt by persons who are on the river or in the neighbourhood of the river. But assuming that to be the case, there still remains the important question, which has been barely touched upon by one or two of your witnesses, and that is how far it affects the health of the people there. Reference was made to a Dr. Jessett. If you could give us some evidence to show that the health of the people suffered from this flow of sewage into the river, it would, I think, be very material, and we should be glad to hear any evidence of that kind. I do not mean to say that a nuisance may not exist without being prejudicial to health; but we want to keep the two things distinct; first, whether there be a nuisance, and secondly whether that nuisance is prejudicial to health. And in considering that latter point you will not forget the hint that was thrown out just now by Mr. Bidder, that it is not enough to show that people are sick in that neighbourhood, but it must be shown that the sickness arises from the sewage, and not from other causes to which in the course of his cross-examination he has more than once referred.

(*Mr. Beaumont Morice.*) I have requested the medical man, Dr. Jessett, to be here in the course of the day, and he will speak with regard to that. I quite appreciate the distinction between the nuisance *per se* and the injury to health, and it has been principally with regard to the nuisance *per se* that I have endeavoured to produce evidence. But I thought it my duty to mention this, having regard to the fact that I have been supplied with a large number of witnesses who would testify to pretty much the same thing, and the Commission might naturally expect that I should give them some information as to the course that I proposed to pursue.

(*Chairman.*) The Commission will, in all probability, at a very early date, take other means of ascertaining whether it is a nuisance or not. We shall visit the place ourselves and examine it carefully, and then we shall be in a better position to test the value of the evidence laid before us.

(*Mr. Beaumont Morice.*) I thought if I formally tendered the remaining witnesses that I have, then, perhaps, the Commission would state whether they thought it desirable to hear any further evidence.

(*Chairman.*) I think we have had quite enough of that kind of evidence for the present, and perhaps you would now give us some evidence relating to the health question. I think you mentioned that you had the surveyor here.

(*Mr. Beaumont Morice.*) I believe he will be here directly. I have understood that he is coming up this morning.

Mr. RICHARD JOHN NAYLOR called in, and examined by Mr. BEAUMONT MORICE.

*Mr. R. J. Naylor.*

28 Nov. 1882.

4115. I believe you live at Woolwich?—Yes.

4116. And you are an ironmonger there, I think?—Yes.

4117. And you are one of the overseers of the poor?—Yes.

4118. How long have you lived at Woolwich?—Nearly 17 years.

4119. How long have you known the River Thames?—I have known the River Thames over 30 years.

4120. Do you remember the outfalls being made?—Yes; I think it was about the year 1865.

4121. Has there been any difference in the state of the river since the time when the outfalls were opened?—I should think that the river has been in a much worse condition since the outfalls were opened than it was before.

4122. In what way?—I notice that as soon as the tide begins to flow a thick muddy substance comes up with the tide, and the smell in hot weather is something intolerable, at times. Of course it depends upon the wind; sometimes it is not so bad as at other times.

4123. Have you had anything to do with dead bodies in the river?—Yes; I had a very great deal to do with dead bodies during that lamentable accident which occurred to the "Princess Alice."

(*Mr. Bidder.*) We have had the coroner and the deputy coroner and his officer up.

4124. (*Mr. Beaumont Morice to the witness.*) In what state did you find those bodies?—They were in a filthy black state, as if they had been black-leaded; they were a sort of blue black.

4125. (*Mr. Bidder.*) Do you mean that they were shiny?—Yes, they looked shiny, as if they had been black-leaded. I think we might attribute that to sewage matter, for this reason: many years ago, before the system of pans and trapping closets was introduced, I have noticed that the insides of water-closet doors were of a bluish-black colour, the same as I have described that these bodies were, and I could only attribute that to the smell that arose from the closet.

4126. (*Mr. Beaumont Morice.*) Was that so on the bodies generally?—On the whole of them. On one day I had occasion to see nearly 500 bodies, and they were all alike.

4127. (*Chairman.*) Nearly all black?—Nearly all black.

4127*a*. (*Mr. Beaumont Morice.*) Have you ever had anything to do with bodies out of other waters?—I have occasionally seen drowned bodies that have been recovered from other rivers, but very seldom.

4128. Has there been any difference between those and the bodies that have been recovered from the Thames?—I have noticed that they have been of a natural colour, and that, as a rule, they were covered with weeds; but in this case the clothing was filthy, and covered with a slimy matter.

4129. Do you know anything about the tides in the river?—No, I do not.

4130. Do you know anything about any sewage coming in near Woolwich, besides the outfall?—Yes; I know that the whole of the sewage from North Woolwich is discharged into the River Thames.

4131. (*Chairman.*) Do you mean at the Crossnes outfall?—No, I am speaking of Woolwich proper.

4132. (*Mr. Bidder.*) Nothing to do with th metropolitan outfall?—No; this is a metropolita outfall on a smaller scale.

4133. (*Mr. Beaumont Morice.*) What do you know about it?—I think about 10 years back a large reser voir was constructed, 250 feet in length and about or 10 feet in diameter, for the purpose of receiving th sewage from that portion of Woolwich which i situated on the north shore, that being discharge into the River Thames by the opening of a penstock which is opened, or should be opened, at every tide but, as I understand, it is not opened at every tide except in wet weather. This particular outfall tha I am alluding to is situated in the parish of Woolwich

4134. Is it marked on the map on the wall?—Yes I think I could point it out to you there. This por tion is in the county of Essex, and in the parish o East Ham, and this northern portion of the parish o Woolwich is in the county of Kent (*describing on th map to the Commission*). This portion might be 25 yards from the hotel in North Woolwich Gardens t the Barge House at North Woolwich. The norther outfall actually discharges its sewage in the metro politan area, which I believe the Act of Parliamen distinctly states that it shall not do. I might say tha they are breaking the law. Then the sewer that am speaking of is somewhere about here (*pointing t the map*); it is just a very few yards above the Nort Woolwich landing pier. I can show it you better o this hand map that I have here (*producing a map an laying it before the Commission*). That black spo denotes Henley's Telegraph Works, and you will se there a roadway called Henley Road. Underneat that road this reservoir is constructed, and the pen stock is opened at low water. That reservoir wa constructed at the expense of the Metropolitan Boar of Works.

4135. (*Chairman.*) Do I rightly understand you t say that that large reservoir is one of the works o the Metropolitan Board?—Yes; and I think the cos was 1,500*l*.

4136. (*Mr. Beaumont Morice.*) Do you notic much drainage coming from there?—Every time it i opened; in fact, it was made larger because it wa not large enough to contain the sewage of the neigh bourhood. At the time I am speaking of there wa a small reservoir there.

4137. (*Chairman.*) Mr. Morice's question is, D you notice sewage coming out of it?—Yes.

4138. (*Mr. Beaumont Morice.*) How often is i opened?—Every 12 hours; every tide, as the tid suits; and the man who opens it is in the employ o the Woolwich Local Board of Health. You must als understand that this portion which I point out here which is called North Woolwich, in the county o Essex, and in the parish of East Ham, also drains int the Woolwich sewer because they have no other mean of drainage.

4139. Therefore, I take it that a considerabl amount of drainage comes out of that sewer?—Cer tainly; I think there are about 250 houses in th parish of Woolwich at that particular spot, and should think there are nearly double that number, o about 500, in the parish of East Ham.

Cross-examined by Mr. BIDDER.

4140. Do you represent this sewage work at North Woolwich as being offensive?—Yes, certainly.

4141. And causing considerable smell?—Yes; I do not say it is all caused from that one particular spot where the small reservoir is, but from the larger one, the northern outfall.

4142. You represent that one as causing a bad smell in the neighbourhood?—Yes.

4143. And a sewage deposit on the mud?—That is so.

4144. That you say from your own knowledge?—From my own knowledge.

4145. And to a considerable extent?—To a con siderable extent. I have occasion to cross the wate very frequently on business matters.

4146. By the Woolwich ferry?—Yes.

4147. That is where you principally notice th smell in the river?—Yes, because sometimes we hav occasion to wait upon the pier for a quarter of a hour or 20 minutes.

4148. I do not know how you came in contact wit those 500 bodies; were you a coroner's officer?—

was overseer. I was called upon as one of the overseers, under this Act of Parliament, to bury the unclaimed dead.

4149. We need not discuss the Act of Parliament. I understand you to say that they looked as if they had been polished with blacklead?—Yes.

*Mr. R. J. Naylor.*

28 Nov. 1882.

Examined by the COMMISSION.

4150. (*Dr. Stevenson.*) How long had those bodies been in the water when you saw them?—Some of them only a short time. The accident occurred on the Tuesday evening, and it was on the Saturday evening and Sunday that the larger number of bodies were brought on shore, but those that were brought on shore earlier were black.

4151. But when did you see them black?—On the Saturday. I was not called upon to see them until the following Saturday.

4152. (*Chairman.*) The accident occurred on Tuesday, and you saw them on the following Saturday?—Yes.

4153. (*Dr. Stevenson.*) Had most of them been taken out of the water on that day?—Most of them had been taken out of the water on Saturday and Sunday; but there were some taken out the same evening. There were some remaining there for upwards of a week, which were not identified.

4154. (*Chairman.*) The accident occurred on a Tuesday; when did you first see any bodies?—About 11 o'clock on the Saturday morning after the accident. That is the first time I saw any bodies.

The witness withdrew.

Mr. WILLIAM EGERTON re-called. Further examined by Mr. BEAUMONT MORICE.

4155. I think you are the surveyor to the Erith Local Board?—I am.

4156. And you have already given evidence here, I believe?—I have. I should like to make a correction with regard to one statement that I made. I made a mistake about the position of Jenningtree Point; I was not aware of the position of it at the time; I thought it was higher up than it really is.

4157. What you are referring to is what you said in answer to question 934, when you were asked about the factories?—Yes.

4158. Will you give the Commission some information with regard to the drainage of Erith. First of all, can you tell us how many houses there are in the parish of Erith?—1883 rateable houses.

4159. How is that number made up?—I do not remember the figures exactly; but if you follow the figures down you will see that they come to 1883.

4160. Of those 1883, how many are drained into the Thames?—507.

4161. That leaves 1376; what is their system of drainage?—They drain into cesspits.

(*Chairman.*) We need not trouble ourselves about them; they do not interfere with the Thames.

4162. (*Mr. Beaumont Morice to the witness.*) For the purpose of draining those 507 houses what sewers are there leading to the Thames?—The public sewer, the outlet to a sewer that runs off the South-eastern wharf; that is a 15-inch iron pipe at the outlet.

4163. Is that what you call the public sewer?—That is the public sewer. There is another public sewer from the Bexley Road across High Street into the Thames; that is a 12-inch pipe.

4164. (*Mr. Bidder.*) Where does that go into the Thames?—Opposite a beershop in the occupation of a man of the name of Wiggins.

4165. Is it near the causeway?—No, it is farther east than the causeway.

4166. (*Mr. Beaumont Morice.*) Is there any other?—There is another that comes down Cross Street, which I think is about a 9-inch pipe, but I am not quite sure. I could not see the outlet; that is only a branch.

4167. (*Chairman.*) Where does that discharge?—That discharges close by the steam flour mills.

4168. (*Mr. Beaumont Morice.*) That is a little above the causeway?—It is.

4169. Is that an iron pipe?—No, it is an earthenware pipe.

4170. Are there any others besides those three?—Not public sewers. There is another 6-inch outlet from some works occupied by Messrs. Shuttleworth and Chapman; it comes out opposite their works.

4171. What are they?—Engineers and shipbuilders. Their works are on the Wheatley Terrace Road.

4172. Is that below the first public sewer that you have mentioned?—Yes.

*Mr. W. Egerton.*

4173. Are there any other sewers besides the three public sewers and the one at Shuttleworth's?—Not that I am aware of.

4174. Are there any what you may call little drainings from the houses?—Ther e may be.

4175. (*Chairman.*) But do you know whether there are?—No, I do not.

4176. (*Mr. Beaumont Morice.*) As the surveyor to the local Board, are these all the sewers that you know of?—All that I am aware of that empty into the Thames. Of course they all empty into the Thames.

4177. (*Mr. Bidder.*) Have you a plan upon which they are marked?—I have not.

4178. (*Mr. Beaumont Morice.*) Do you know anything about the gulleys which lead into those sewers?—Yes; from all the public roads where the surface water is drained into the sewer there are catch traps or gulleys.

4179. Are those attended to from time to time, to your knowledge?—Yes they are.

4180. How often are they attended to?—They vary from a week to a month. If there are heavy rains they are attended to every week; and in dry weather, when there is very little water going in, perhaps they are not attended to for three weeks or a month.

4181 But you know as a matter of fact coming within your own knowledge that they are attended to from time to time?—I do.

4182 Have you any information as to how many persons there are in those 507 houses which are drained into the Thames?—We generally reckon about five to a house, and that would make it about 2500.

4183. You know where the mud lies about Erith?—Yes.

4184. Are there any sewers where the mud lies thickest?—No; where the mud lies thickest is nearly opposite the two ballast wharves. I might remark that where the largest sewer is there is less mud and filth; that is the 15-inch sewer.

4185. That is opposite the South-eastern wharf?—Yes.

4186. That will be below Erith Pier?—Yes. I noticed it this morning more particularly; I have been round there this morning.

4187. Can you tell us how far that main sewage pipe runs into the river at low water?—I could scarcely tell you; I should think 80 yards, but I have never measured it, and I could only guess at it.

4188. (*Mr. Abernethy.*) Does it run to low-water mark?—No.

4189. (*Mr. Beaumont Morice.*) Can you tell us how far it is out of the water at low water?—No, I could not.

Cross-examined by Mr. BIDDER.

*Mr. W. Egerton.*

28 Nov 1882.

4190. First, with regard to these sewers, the rest of the houses, you say, drain into cesspools?—Yes.

4191. Have those cesspools no overflow?—No, they have not.

4192. None whatever in any case?—Not that I am aware of.

4193. They are absolutely self-contained?—So far as I know.

4194. You have mentioned several outlets into the river; am I right in identifying the 15-inch pipe, that you mentioned first, as being situated opposite the Erith Gardens, a little below the pier?—Yes.

4195. I am told that what are called the Erith Gardens are not gardens now?—No, they are not; it is the South-eastern wharf.

4196. And close to the wharf of that gentleman who gave evidence the other day, and said that his men complained of the smell when they were clearing away the mud?———

4197. (*Chairman.*) Is it near the house of Mr. Beadel?—No.

4198. Near whose place of business is it?—It is near Mr. Beadel's place of business; it is known as the South-eastern wharf. Mr. Frank Beadel lives not far from the outfall. Messrs. Easton, Anderson, and Company's and Messrs. Shuttleworth and Chapman's are the two places of business.

4199. (*Mr. Bidder.*) I am right in identifying this pipe as being near that wharf?—Yes.

4200. About how many feet is it from it?—As I have already said, I think it might be about 80 yards.

4201. Is the end of the pipe in a fractured condition, so that the sewage does not go to the end of it?—I do not know.

4202. Is there also an outlet which I do not identify with any of those you have mentioned, about 15 inches in diameter, close to the Erith Causeway?—No; there is one that I said was about 12 inches near the Erith Causeway.

4203. Perhaps we are talking of the same thing; is it immediately above Erith Causeway?—No, below it.

4204. How far from the causeway?—Perhaps 50 or 60 yards; I will not say exactly.

4205. Are you not aware that there is an outlet from which either sewage, or water, or some liquid, is discharged into the river immediately above the Erith Causeway?—That is the one that I spoke about as being a 9-inch earthenware pipe.

4206. How far is that from the causeway?—Perhaps it might be 30 yards, but I have not measured it.

4207. According to your memory, there is one 60 yards below and another 30 yards above?—Yes.

4208. Many of those sewers, whatever the amount of the population may be, are very offensive in the matter that they discharge, are they not, and cause a considerable nuisance upon the banks of the river?—I do not know, I am sure. I should think there is more caused by the mud that accumulates from the outfall than there is by them.

4209. Did your board some four or five years ago invite an engineer of eminence to report upon the sewers of Erith?—I do not know that they did.

4210. Did you ever hear of Mr. Edward Easton?—I know Mr. Edward Easton, and I know that he prepared a scheme for draining Erith.

4211. Did he report upon the state of the drainage?—Yes, he did.

(*Mr. Bidder.*) I should like to ask my learned friend, Mr. Morice, whether he produces that report?

(*Chairman.*) I have no doubt that you will produce it if he does not; and, therefore, it seems to me that you will probably supply us, by some evidence of your own, with very far more authentic evidence of what you are trying to prove through this witness.

(*Mr. Bidder.*) So I shall at the proper time; but now the surveyor of Erith is here, and it is my bounden duty to put to him, and to give him an opportunity of contradicting, if he thinks proper, that which I am going to rely upon.

(*Mr. Beaumont Morice.*) I have no doubt that I shall be able to supply the report which my learned friend alludes to.

4212. (*Mr. Bidder to the witness.*) I want to know whether these are facts within your knowledge. To begin with, there is a sewer with a 15-inch pipe, which I have no doubt is the one you have already mentioned; do you know how many houses that drains?—No, I do not remember.

4213. Now, with regard to some other matters which I did not ask you about before, you have frequently had occasion to be consulted as to steps being taken with regard to the nuisance, smell and otherwise, arising from the factories at Erith about which complaints have been made?—Yes.

4214. Did you have a petition to the local authority in September 1880, two years ago, by a number of the ratepayers of Belvidere in respect of the serious nuisance arising from the factories on the river banks?—I could not say; it might have been handed to the local board, and I might not know about it. I do not remember it.

4215. I find from a paper of that date that this purports to have happened; that a memorial signed by 69 ratepayers——

(*Mr. Balfour Browne.*) That is not evidence.

(*Mr. Beaumont Morice.*) I do not want to interrupt my learned friend unnecessarily, but I really must take exception to this.

(*Chairman.*) The question is whether a certain memorial, of which you are seeking to give the contents, was presented to the Erith Board. If that memorial is to be in evidence it should be put in. If it is not, then it is a question whether the witness can charge his memory with the contents of that memorial.

(*Mr. Bidder.*) The people of Erith are here as memorialists complaining of smells and other nuisances in that neighbourhood, and attributing them to the outfalls of the Metropolitan Board. At the proper time I shall endeavour to show by evidence of my own that they are not attributable to the outfalls of the Metropolitan Board; I also venture to say that to a great extent they are attributable to other causes. Part of the evidence bearing upon that, it is not within my power to produce, because, for instance, the Acts of the local board are within their own knowledge, and more accessible to them than to the Metropolitan Board; and the best opportunity I can have is, when I get officials of the local board into the box, to cross-examine them as to whether complaints were not made or proceedings taken with reference to these other nuisances.

(*Chairman.*) You want to elicit a fresh fact, viz., that there has been a complaint in writing. If that complaint has been made in writing, the only way for you to bring it out in evidence is to produce that writing.

(*Mr. Bidder.*) It is not for me to produce that writing; I have not got it.

(*Chairman.*) I do not think that the question can be admitted.

4216. (*Mr. Bidder to the witness.*) Is it not within your knowledge that, in consequence of representations made to the local board, officials of the board were put in motion to take steps with reference to nuisances caused by the factories, in the autumn of 1880?—I do not know when the time was; but I believe it was so.

4217. Who is Mr. Ogston?—He is a professor of chemistry, I think; an expert.

4218. Was he employed by the local board?

(*Mr. Beaumont Morice.*) I think, if my learned friend will refer to the previous examination of this witness, he will see that we have had this before. At question 1027 he was asked about all these factories.

(*Mr. Bidder.*) I am not asking about the fish manure. Would you mind, sir, intimating to the other side that, in the opinion of the Commission, the original memorial should be produced? I cannot produce it.

(*Chairman.*) You can give them notice to produce it.

(*Mr. Beaumont Morice.*) I shall be very happy to produce anything that the local board possess upon the subject.

4219. (*Mr. Bidder.*) Then I pass on from that. (*To the witness.*) In January 1881, did you, as surveyor, report to the board upon a ditch at the back of Messrs. Price's works as being a nuisance?—I do not remember the date, but I have reported upon that.

4220. Was that a serious nuisance, in consequence of the offensive matter in it?—I should consider it a serious nuisance.

4221. Producing offensive smells, which were annoying to the residents in Erith?—Yes.

4222. (*Chairman.*) Was it an open ditch?—Yes.

4223. (*Mr. Abernethy.*) What was the size of that ditch?—I should think it was about 6 feet wide. The water in the lower part was not more than a yard wide at times; but in times of heavy rains it was much fuller.

4224. (*Colonel Ewart.*) Is this ditch in direct communication with the River Thames?—Yes, it has an outlet into the Thames.

4225. (*Mr. Bidder.*) Have the complaints on the part of the inhabitants as to the factories continued down, I may say, to within a few days of the present time?—Not that I am aware of.

4226. Was not a letter of complaint received by your board, and read at a meeting on the 17th of last October, with reference to the smell from the oil mills?—It may have been, but as I am never in the board room during the time of meeting, I cannot say.

4227. (*Chairman.*) Did you hear such a letter read at the board?—No, I did not.

4228. (*Mr. Bidder.*) You are directed to report upon these cases afterwards, are you not?—I have not been directed to report upon that case so lately as the 17th October.

4229. When were you last asked to report upon the oil works?—I do not remember.

4230. In this present year?—It may have been; I cannot say.

4231. (*Chairman.*) Are you speaking of Price's oil works?—Yes.

4232. (*Mr. Bidder.*) Have you any book, or account of your official work?—I have no diary.

4233. Have you any book in which you record them when you make inspections as surveyor?—No, I do not know that I have; I may have it in some of my pocket books.

4234. Am I wrong in saying that you have frequently had, as part of your duty, within the last two years to visit and report upon various factories which have been complained of as nuisances?—Yes, I think I have within the last two years.

4235. Frequently?—I do not say frequently.

4236. (*Mr. Abernethy.*) Do any of these factories discharge refuse into the Thames?—No, except the ditch at Price's factory that I have been speaking of before.

4237. (*Mr. Bidder.*) Is there a dung wharf fronting the river at Erith?—Yes.

4238. At which manure is loaded or discharged?—At which manure is discharged, not loaded.

4239. Have there been many complaints as to the nuisance caused by that dung wharf?—Not this year that I remember. I have had no complaints this year, but I have had complaints previously respecting the smell from the dung wharf.

4240. But you do not recollect having had any in the year 1882?—No.

4241. Have your board gone so far as to prosecute people for landing particularly offensive manure there?—I think so in one instance, but that I am not sure of; it was, I think, for letting manure remain a longer time than it should remain.

4242. But the cause of the prosecution was, of course, the nuisance created to the inhabitants?—It was for letting the dung remain too long.

4243. (*Chairman.*) You were not prosecuting, were you?—No, the board prosecuted.

4244. (*Dr. Stevenson.*) I suppose you would take out the summons?—No, I leave that to the solicitor. I think it was the clerk who filled it up, and I got it signed by the magistrates.

4245. (*Mr. Bidder.*) Did you give evidence?—Yes.

4246. Did you also make a formal report on various factories, very late in last year, in the November of last year?—I do not remember without referring back to the dates.

4247. Have you copies of your written reports?—I think I have.

4248. Can you produce them now?—I cannot.

4249. Do you remember, in the November of 1881, reporting on Messrs. Callendar's works, Messrs. Price's works, Messrs. Berger and Spence's works, and Messrs. Collins' works?—I think it is very likely that I did, but I do not remember the time.

4250. Did you report, as you told one of the Commissioners just now, to the effect that there was no drainage from those works?—

(*Chairman.*) Was the report in writing.

(*Mr. Bidder.*) If I cannot get the report, I must get the best I can.

(*Chairman.*) You cannot put in secondary evidence in this sort of way.

(*Mr. Bidder.*) But those who have the report do not produce it.

(*Chairman.*) You do not call upon them to produce it.

(*Mr. Bidder.*) Then I invite them now to produce it at the next sitting of the Commission.

(*Mr. Beaumont Morice.*) I am not aware at the moment that there is such a report; but I will endeavour to ascertain whether there is, and if there is I will undertake to produce it. But I would draw the attention of the Commission to what has already taken place here as to this matter. At question 1067 this witness was asked about having seen these factories, and whether they had been better or worse. Then he was asked whether any action was taken by the board, and his answer was "No; only notices were given, and "some alterations were made in the machinery and "in the condensers and the furnaces. (*Q.*) Was that "in consequence of a report made to the board?" (*A.*) It was"; so that my learned friend has really what he wants.

(*Mr. Bidder.*) My learned friend suggests that because he, in re-examination, asked a certain question and got a certain answer which pleased him, I am not entitled to cross-examine the witness.

(*Chairman.*) If these matters were really material, I should be more inclined to waive the question about the strict admissibility of the evidence, but I do not see what the point of it is at present. That you will be able, Mr. Bidder, to give us evidence that there are a number of offensive factories on the banks of the river I have not the slightest doubt, because it is a matter of notoriety.

(*Mr. Bidder.*) I am going to suggest to the Commission, when it comes to my turn, that the offence and nuisance of which the people of Erith complain is attributable, and is attributed by themselves, to a distinct cause; and, therefore, when I have the surveyor of Erith in the box giving evidence, it is my right, and not only my right but my duty, to put it to him.

(*Chairman.*) If you want his reports to his board, the proper course is to give the board notice to produce those reports, and no doubt Mr. Morice will at once produce any documents that you may require and that he possesses.

(*Mr. Beaumont Morice.*) Certainly.

4251. (*Mr. Bidder.*) I indicate a report which was presented at a board meeting held on the 8th November 1881. I will give my learned friend a list if there are any others that I want. (*To the witness.*) Is it a fact (because you said just now that there was no offensive drainage from these works) that from Messrs.

*Mr. W. Egerton.*

28 Nov. 1882.

Collins' works you have found both offensive stagnant water and offensive drainage?—That was from the hides and material lying on the river wall, which drained into the Thames.

4252. (*Chairman.*) You found offensive matter?—Flowing from the refuse that lay on the river wall, on the surface. There is no drain there.

4253. (*Mr. Bidder.*) But it drained into the Thames?—It drained into the Thames.

4254. (*Mr. Abernethy.*) Did that arise from rain falling on it?—Yes, that is all.

4255. (*Dr. de Chaumont.*) Are you inspector of nuisances for the local board as well as surveyor?—Yes.

4256. (*Mr. Bidder.*) Is it within your knowledge that about the close of last year a communication was made to your local board from the Local Government Board with reference to the complaints of persons of the offensiveness of those factories?—I am not aware of it.

(*Mr. Bidder.*) I ask my learned friend to produce a communication from the Local Government Board to the Erith Local Board.

(*Mr. Beaumont Morice.*) If my learned friend will give my clients notice, I will endeavour to do everything that is possible in the matter.

4257. (*Mr. Bidder to the witness.*) Do you remember that a committee of your board was appointed at the end of last year to investigate the question of the nuisances produced by the factories?—No.

4258. (*Chairman.*) Do you attend the meetings of the board?—No; I am not admitted to the board room. I get my instructions after the board meeting is closed.

4259. (*Mr. Bidder.*) At the end of last year did you assist a committee of the board in investigating the question of the factory nuisances?—I did some time last year, but I do not remember the time.

4260. Who were the members of that committee?—I do not remember who the gentlemen were.

(*Mr. Bidder.*) I will ask my learned friend to produce the report of that committee, if it exists, upon the question of the nuisance.

(*Mr. Beaumont Morice.*) We have the result of that in evidence already.

(*Chairman.*) Mr. Bidder's clients will of course give Mr. Morice's clients notice of the documents that they require, and they will be produced, I have no doubt, and we shall have authentic evidence on all these matters.

4261. (*Mr. Bidder to the witness.*) Have you been engaged also in this present year in reporting upon the nuisances of the factories?—No, I have not, since the new Act came into operation.

4262. When did the new Act come into operation?—On the 1st of January, I think it was.

4263. Besides the factories, have you recently had complaints of local nuisances, from cesspools and other offensive matters, compelling the people to keep their windows shut?—No.

4264. Did you not report, in May of this present year, upon a nuisance of that nature affecting houses in Picardy Street, Belvidere?—Not so bad as to have to close the windows. I may have reported, but I cannot say exactly.

4265. (*Chairman.*) Was it to you that the complaint was made?—I do not remember whether it was or was not.

4266. (*Mr. Bidder.*) You say that you had to report upon it?—If the notice was sent to me I should give them notice at once to abate the nuisance, and I should see that it was abated.

4267. But did you not make a report to the board?—I cannot remember.

4268. Do you know a gentleman of the name of Clare, who lives in Picardy Street, Belvidere?—I do not remember the name. I do not know the occupiers of the whole of the houses in Picardy Street.

4269. Have you had frequent occasion lately to serve notices to abate local nuisances?—I have served some notices.

4270. Are there certain manure works at Belvidere?—There are Collins and Company's works, and Proctor and Bevington's works, as I said before; but, as I have already said, I have not visited them this year.

4271. Were there complaints of these manure works in the summer of this present year?—I do not know.

4272. Was Mr. Ogston called in to report upon them, to your knowledge?—No, I do not think he was.

(*Mr. Bidder.*) I think perhaps it will save time if I ask my clients if there are any further reports that they desire to have produced, and then a list of them shall be made and furnished to my learned friend, Mr. Morice.

Re-examined by Mr. Beaumont Morice.

4273. You had complaints with regard to Picardy Street and other streets in the ordinary course of your business?—Yes; and I have copies of all my reports and notices, and they can be produced at any time.

4274. You have been asked about a ditch; can you tell us whether any action was taken with regard to that ditch?—Notice was given to Messrs. Price and Company in the ordinary course to abate the nuisance.

4275. Do you know whether there has ever been any alteration in the ditch?—Yes; they have had it all cleared out since.

4276. When was that?—Last year.

4277. With regard to these reports and inspections that you have made, what did they refer to?—Very great alterations in the process of the manufacture, and a very great abatement in the nuisance.

4278. Did you, as local board surveyor and inspector of nuisances, inspect those factories?—I did very frequently at one time.

4279. And until the coming into operation of the Alkali Act did you continue to do so?—Yes.

4280. And since you have inspected those factories has the smell from them been better or worse?—Very much better indeed.

4281. Do you know what became of that prosecution about the dung wharf?—No, I do not.

4282. The wharf is merely used for the purpose of landing; is that so?—That is all.

Examined by the Commission.

4283. (*Colonel Ewart.*) Are those 507 houses which you spoke of, which are drained into the Thames, modern houses or old houses?—A great number of them are cottages. Very few are old houses; they are mostly modern houses.

4284. Have they been built, do you suppose, during the last 17 years?—Yes; some of them; some of them were built previously to that time; some have been built 20 years.

4285. They are mostly cottages, you say?—Mostly cottages.

4286. Is there any distinction between those that have cesspits and those that are drained into the Thames as regards their age; are the cesspit houses the old houses or the modern houses, generally speaking?—I should think there are rather more new cottages that are drained into the Thames than old houses.

4287. Has there been any great increase in the population of Erith in the last 17 years?—Yes, there has been a great increase in the population.

4288. Do you know the number?—No, I do not, but I should think about a third more.

4289. In the case of those houses that drain into cesspits, what becomes of the slops, as they are technically called. The solid matter goes into the cesspits, I suppose?—And the slops the same. It all goes into the cesspits.

4290. But you said that they had no overflows?—They have no overflows from the cesspits.

4291. Are those porous cesspits?—Some of them

are, to a certain extent, where they have got into the gravel. In some places it is like putting the sewage into a pan, and they are emptied and taken away—on to the land mostly—by the farmers in the night.

4292. Are they frequently emptied?—It depends very much upon circumstances. I have had one cesspit emptied twice this year, and it was eight years since it was emptied before.

4293. Then the slops do not go into these drains which you have spoken of, which discharge into the sewer?—The slops and all go into the sewer where they are drained into the sewer.

4294. That is in the case of the 507 houses; but not from the other houses?—No; not from one of them that I am aware of.

4295. Have you any gasworks?—Yes.

*Mr. W. Egerton.*

28 Nov. 1882.

4296. What becomes of the refuse from those?—The ammoniacal liquor is put into barges and sent to London for some purpose; I do not know what.

4297. Nothing goes from these works into any drain?—Nothing.

4298. (*Dr. Stevenson.*) When you visit these factories, do you make your reports to the board in writing?—Yes.

4299. And you take notes when you visit them?—Yes, I take notes, and there are copies of all my reports.

4300. Although you do not keep a diary, you have notes of all your visits to those places?—Yes.

The witness withdrew.

Mr. JOHN WILLIAM SHOWELL called in, and examined by Mr. BEAUMONT MORICE.

4301. I believe you live at Greenwich?—Yes.

4302. And you are the deputy harbour-master?—I hold the warrant.

4303. And you are the inspector of nuisances and explosives, and things of that kind?—Yes.

4304. What part of the river is your particular district?—The lower part.

4305. Can you tell us the limits?—From Greenwich to Greenhithe and Long Reach.

4306. How long have you known the river?—From my boyhood; all my lifetime.

4307. You remember the outfalls being opened at Crossness and Barking?—Yes.

4308. Has there been any difference in the state of the river before and since that time?—Yes, a great deal of difference.

4309. In what way?—By reason of the pollution of the river and the bad water.

4310. In what way specially?—From the sewage.

4311. Do you see any difference in the water?—It is a different colour.

4312. Is it thicker?—A great deal thicker.

4313. Is there anything else that you notice?—There is a great deal of filth and sewage with it.

4314. Has it any smell?—There are great smells from it.

4315. You know the mud up and down the banks of the river?—Yes.

4316. Has there been any alteration in that lately?—None.

4317. Has there been any alteration in it as compared with the time before the outfalls were opened?—The mud is a different colour.

4318. Is it like ordinary mud?—No; it is more like a black substance, filth, and such like.

4319. Is that the case in one part more than in another?—No, along the shores.

4320. I suppose you know about the tides in the river pretty well?—Yes.

4321. Can you tell us how far anything put into the river at Crossness would get down on a neap tide?—I should think somewhere about the upper part of Gravesend Reach.

4322. Can you tell us how far it would come back on the flood?—To the best of my judgment I should think about Tripcock Point.

4323. That is above Crossness?—Yes.

4324. Do you consider that the flood is stronger than the ebb, or not?—You would drive further on the flood than you would on the ebb.

4325. So that it would drive further back than it would go down?—Yes.

4326. Can you tell the Commission from what you have noticed whether the sewage matter passes down the river or settles down in portions of it?—It settles down in portions of it.

4327. Whereabouts do you say it specially settles?—From which sewer; at Barking or Beckton?

4328. Say Crossness?—Then it settles about the lower part of Halfway Reach, and off mid-channel and then round Erith Bight.

4329. You know Erith Bight and all round there?—Yes.

4330. Can you tell us what the stuff that settles there is like?—Human dung.

*Mr. J. W. Showell.*

4331. Has there been any increase in that during the last few years?—A great deal.

4332. In the case of Barking what becomes of it?—Down along below Barking there is a great settlement of mud or filth, and right away to the lower part of Dagenham.

4333. Is the stuff that settles there like what you have told us in the other case?—Yes.

4334. Your duties are, I believe, to look after what comes into the river?—Yes.

4335. Can you tell us, from your own knowledge, what gas or chemical or other manure drainage comes into the river?—There is none that comes into the river, only through the sewerage.

4336. Is it a part of your duty to investigate anything that does come in?—Yes, it is.

4337. What would you do in the case of anything coming in?—I carry bottles, and I should take a sample from any works where I saw anything coming in.

4338. As a matter of fact, have you had occasion to do that during the last few years?—I have not.

4339. Therefore, in your opinion, is it true that chemical or manure drainage has killed the fish that used to be in the river?—I should think so; the sewerage.

4340. Due to what cause?—From the filth and that which comes through the sewerage.

4341. Can you tell the Commission how deep any of these deposits that you have told us about are?—I have let go my anchor, and I have found that there has been 8 or 10 feet in some places; I have not been able to reach it with my boat-hook.

4342. What has that been?—All slime and slush.

4343. What used there to be there years ago to your remembrance?—Hard shores.

4344. Do you know the chemical factories down the river in your district?—Yes.

4345. What are they, starting from Crossness?—There is only the factory belonging to Messrs. Price, the oil refiners.

4346. What are there above, between that and Barking?—There is nothing on the south shore. On the north shore there is the factory belonging to Messrs. Davis, the tar distillers, in Barking Creek; and that is all above Barking.

4347. Are you prepared to say that no refuse comes from them into the river?—I am.

4348. Had you anything to do with the Dutch eel-boats that used to come up the river?—I used to have to do with them.

4349. How many years ago is that?—40 years ago.

4350. Can you tell us from your own knowledge why they ceased to come up the river?—On account of the water going bad.

4351. How many years ago was that?—It is about 30 years since they first shifted.

4352. Where did they go then?—To Stoneness Point.

(*Chairman.*) We have had nobody called who says that he caught those eels or that he had to do with them, but it is all hearsay.

(*Mr. Balfour Browne.*) We propose to call the persons themselves.

Cross-examined by Mr. Bidder.

*Mr. J. W. Showell.*

28 Nov. 1882.

4353. What are your duties?—To see that there is nothing polluting the river.

4354. By whom are you appointed and to whom do you report?—The Thames Conservancy Office.

4355. How long have you held the appointment?—I have held the appointment of inspector for these six years.

4356. I believe you have other duties, have you not; such as superintending the removal of powder, and things of that kind?—I have to see it.

4357. You say that to your knowledge, since you have been inspector, there have been no offensive matters within your district poured in the river, excepting from the sewers of the Metropolitan Board?—That is all I have taken notice of in my travels.

4358. Do you know the Beckton Gasworks?—Yes.

4359. Are you aware of a sewer there?—I am aware of a large pipe there.

4360. What is its diameter?—I have not measured it.

4361. Is it about three feet in diameter?—I should think so.

4362. Is liquid discharged from that pipe into the river at the present time?—No.

4363. How long is it since any was discharged into the river from that source?—I cannot say; I have never seen any.

4364. Will you undertake to say that that pipe has not been discharging frequently during the present year?—Not that I have seen.

4365. When did you visit it last?—I was there last Friday.

4366. For the purpose of inspecting?—Yes.

4367. What was your business then?—Looking at other places, and different things.

4368. Do you go into that pipe?—No, I did not.

4369. When did you last inspect that pipe to see if anything was coming from it?—You can see the water, but you cannot walk to it in the mud.

4370. When did you last, in the discharge of your duties, inspect that pipe to see whether offensive matter was discharging through it into the river?—I was there about a fortnight ago.

4371. Did you go for the express purpose?—No.

4372. I did not ask you when you were in the neighbourhood of the pipe; but when you were there last what purpose were you there for?—To look at other things up and down along the shore.

4373. Being there, did you go in to inspect the pipe?—Not purposely.

4374. You simply passed it in the boat rowing along?—Yes.

4375. When did you go for the purpose of making an inspection of that pipe?—A fortnight ago.

4376. You say that you happened to be going on other business?—No, I did not.

(*Chairman.*) He said that he was going on a variety of business, and that as he was going he did inspect that pipe.

4377. (*Mr. Bidder to the witness.*) At what time of the tide was it?—It was about half-ebb.

4378. Was the pipe uncovered?—No.

4379. How could you, without going in for the purpose, the pipe being covered, casually passing by and being on other duty, tell whether the matter was discharging from that pipe?—By the colour of the water and the mud on the shore.

4380. Have you ever, during the present year I will say, gone to look at that pipe at a time when the water would permit of your seeing it for the purpose of ascertaining whether there was a discharge from that pipe?—I have.

4381. When?—On several occasions.

4382. When last?—I will not say exactly when last. I have walked there.

4383. This year?—Yes, this year.

4384. When did you go there last?—I cannot say what the date was.

4385. Was it in the summer?—In the summer, and since.

4386. Have you seen it at low water?—Yes.

4387. You have never seen anything discharging from it?—I have seen the water running from it.

4388. You told me before that you had not?—Nothing offensive, I said; but you can always see water running out of it.

4389. Since you have been appointed inspector you have never seen anything offensive coming from that pipe?—No.

4390. Have you frequently reported to the Conservators offensive discharges into the river?—No.

4391. Have you reported on any this year?—No.

4391*a*. Or last year?—No.

4392. Or the year before?—No.

4393. Have you ever reported on one?—No.

4394. In point of fact is not your time principally taken up in superintending the powder business?—No.

4395. Now as regards another matter; you have said that the sewage deposits are at several places, and I want to see whether I have rightly ascertained those places. Am I right in saying that one of them is a large bank on the south side of the river opposite to and below Crossness?—Yes.

(*Chairman.*) All this we have had. There can be no question of the existence of these mud banks, can there.

(*Mr. Beaumont Morice.*) Not at all. The point that I put was merely the composition of them, according to this witness's knowledge.

(*Mr. Bidder.*) I thought that mud bank question had been pretty well disposed of. The witness comes and gives evidence as to where the sewage deposits; therefore I ask him a question in order to identify the place with the mud banks which we have already discussed. That is surely a proper thing for me to do, in order to show that this witness is speaking of the same mud banks as the other witnesses.

(*Chairman.*) Of course.

(*Mr. Bidder.*) If it is taken that he is, I am perfectly content.

(*Chairman.*) I did not understand him to start any fresh mud banks upon you.

4396. (*Mr. Bidder.*) If that is clearly understood I am entirely relieved from cross-examining him any further upon that matter. (*To the witness.*) One question about the tides; have you ever made any experiments upon the tides?—No.

Examined by the Commission.

4397. (*Dr. Stevenson.*) What is the colour of the water that comes out of this pipe at Beckton?—We should see if there were any different colour in it from the pure water; it would soon show itself.

4398. Then it is not the water that comes out of the pipe that is of a different colour?—No; if it had any colour at all it would lie on the mud and you would see it.

4399. (*Chairman.*) You say that when you inspected this pipe last Friday week, or fortnight, it was under water?—Partly under water.

4400. Could you see anything coming out from the pipe?—No.

4401. Then how could you tell whether there was any noxious matter coming out?—The water was coming out; but the noxious matter would soon colour the water there.

4402. (*Professor Williamson.*) Can you tell me whether the pipe which you mentioned as coming from the Beckton works discharges water in dry weather as much as in wet weather?—Not so much in dry weather as in wet; it does not run so long.

Re-examined by Mr. Beaumont Morice.

4403. Do you know whether this pipe takes off the land drainage?—That is what it is for, for taking off the surface water, the land drainage.

4404. Do you know further whether what comes out is filtered before it comes out?—I do not know.

*Mr. J. W. Showell.*

28 Nov. 1882.

The witness withdrew.

Mr. William Evans called in, and examined by Mr. Beaumont Morice.

*Mr. W. Evans.*

4405. I believe you live at Woolwich?—Yes.

4406. And you are an under-waterman?—Yes.

4407. What are your duties on the river?—Our under-water work is grappling, dredging, and feeling for things, and putting dogs into the cast, and lifting the things from underneath the mud.

4408. To take it shortly, your duty is grappling for things in the river?—Yes.

4409. From the opportunities that you have of seeing it in carrying out your work, can you tell us what is the state of the river?—The state of the river is such that when I put my grapplings overboard, I cannot go but a very little distance before they are choked, and they are no good to me; there is so much filth underneath of all sorts.

4410. There is a lot of filth, is there?—There is a lot of filth, sewage sort of stuff, which is nothing but slime and filthy stinking mud; and when we move it, it is like a lot of oil on the top of the water, and you can hardly bear the stench of it in the summer time.

4411. Have you ever seen any worms?—I have. I have seen some long red worms, several inches in length on my grappling ropes, my boats' cables. It is not a fish-feeding worm, it is a long red worm that eats all the substance of the rope if it is in the water many days; it rots the rope.

4412. It is not a fish-feeding worm you say?—

4413. (*Mr. Bidder.*) It is a rope-feeding worm?—Yes.

4414. (*Mr. Beaumont Morice.*) That you find on the muck and stuff that comes up?—Yes, on the rope.

4415. Have you ever, in going up and down the river, noticed when the sewage comes out at the outfalls?—I have rowed by on a moonlight night, when I could see the clock, as near as I can say between one and two and three o'clock, and it has been about three hours flood; I have rowed from Grays Black-shelf after having laid to there about three hours; and by the time I wash up my nets and get under weigh, and get up to the sewerage, it is about half-flood, about two hours before high water, and the water coming out of this outfall has shoved my boat on one side.

4416. That you say is before high water?—Yes.

4417. Have you ever noticed the river, especially at low water, when steamers have been going up or down?—Yes, up.

4418. What has been the effect of steamers going up the river at that time?—I have seen a boat trying to anchor in the Government moorings, outside the "Fishguard," opposite the stairs, and I have seen that boat get aground. Where the channel is now, instead of being the south channel it is the north channel.

4419. (*Mr. Bidder.*) Where is this?—Right opposite the dockyard stairs at Woolwich, outside where the "Fishguard" lay, which lies at Greenwich now.

4420. (*Mr. Beaumont Morice.*) When the steamer was passing up was there any stench from the water?—She was aground.

4421. As the steamer passed up was there any particular stench or stink?—Yes, very bad indeed in the summer time; shocking bad, and as black as ink.

Cross-examined by Mr. Bidder.

4422. When was it that you saw the sewage coming out before high water?—That was, I think, in the latter part of last July twelvemonth.

4423. Where were you coming from?—From Grays Shelf, what they term Black Shelf, just below Greenhithe.

4424. Did you start from there at half flood?—About half an hour or three-quarters of an hour after low water.

4425. What were you doing there?—Catching shrimps on Grays Shelf.

4426. Do you know at what time it was high water that night?—I cannot exactly say, but I think it was between about three and four o'clock, or after that; it must have been about five o'clock.

4427. You do not recollect the day?—No, I do not. I had no occasion to take notice of the day.

The witness withdrew.

Mr. Frederic Bowreman Jessett called in, and examined by Mr. Beaumont Morice.

*Mr. F. B. Jessett.*

4428. I believe you live at Erith, and you are the medical officer of health for the district?—I am.

4429. How many years have you been there?—Between 12 and 13 years.

4430. During that time what has been the condition of the River Thames?—Of late years it has been very bad. When first I came there young men used to bathe off the end of the pier constantly at high tide, in the early morning, before they went up to London to their business. Now such a thing would be totally impossible.

4431. Why would that be impossible?—Because of the contaminated state of the river.

4432. From what cause?—Undoubtedly from the sewage from the outfalls.

4433. Has that been increasing much during the last few years?—Considerably.

4434. Have you ever had occasion to treat persons for illness caused by this matter?—I have. There are several cases that I could name in which, I believe, the illness has been chiefly owing to the contaminated state of the river. I remember one case in which a new man came down to the cutter "Spray," the Thames Police yacht, and he had not been on board above a week before he was seized with most violent diarrhœa and sickness.

4435. When was this?—About the spring or the middle of last year.

4436. (*Chairman.*) What was the man's name?—I cannot tell you his name from memory.

4437. (*Mr. Beaumont Morice.*) He was suffering from diarrhœa?—He was suffering from diarrhœa and vomiting.

4438. In your judgment was that due to the state of the river?—I treated him on board the yacht for some few days, and finding that he got no better, I removed him; and shortly after his removal, within a day or two, he got completely well.

4439. (*Professor Williamson.*) Had the man been sleeping on board the yacht?—He had.

4440. (*Mr. Beaumont Morice.*) And you removed him on shore?—Yes.

4441. (*Professor Williamson.*) Did he get better afterwards on shore, or did he continue to be sick?—He got better very shortly after being on shore.

4442. (*Chairman.*) And recovered?—And recovered.

4443. (*Mr. Beaumont Morice.*) Can you tell us of any other cases?—A number of men who have been working in the mud, moving the mud from the different wharfs, have come to me from time to time suffering from diarrhœa and sickness.

*Mr. F. B. Jessett.*

28 Nov. 1882.

4444. You have attended men at the ballast wharf too, have you not?—I have.

4445. And you say that their illness is due to the same cause?—I believe it to be.

4446. (*Chairman.*) What were those men from the ballast wharf engaged in doing?—Removing the mud from the ballast wharf to keep the way clear for the vessels to come up.

4447. (*Mr. Beaumont Morice.*) Can you say whether this has been so to any general extent with persons working upon the banks of the river?—We have never had any epidemic of it.

4448. But have there been many cases of it amongst persons who have been working upon the banks of the river?—A fair number; I will not say many, but there have been several cases.

4449. What is the condition of health of the parish of Erith?—It is very healthy.

4450. Can you account for its being very healthy, notwithstanding the state of the river?—I believe that there are several causes. I believe one cause is that it is entirely a new place; the cottages are nearly all recently built; and in Erith proper the greater number of cottages are drained; and lately we have closed nearly all the wells in the place, and they have the company's water laid on. Further than that, I think that the fact of the soil at Erith being a good sound gravel tends to the healthiness of the place. We have had a number of wells closed within the last six or seven years, because we had some cases of typhoid fever in the town, and we find that wells contiguous to the river are polluted with sewage. Of course I cannot prove it, but I have very little doubt that all those wells are tidal wells, that is to say, that at low tide the wells are empty and at high tide they are full; and I think it quite possible that where the water can run away through any chink, or what not, the sewage might soak back and so contaminate the wells close by the river.

4451. By virtue of your position as medical officer of health, I believe you have recommended the closing of many of these wells?—I have, of several of them. They have been analysed by the public analyst and condemned.

4452. (*Dr. de Chaumont.*) Were the cases of typhoid fever chiefly in the houses that had tidal wells?—Yes, chiefly. It is generally on account of cases of typhoid fever that our attention has been drawn to the state of the wells, and we have had the water analysed.

4455. (*Dr. Stevenson.*) What is the condition of the cesspools there generally?—In that district there are very few cesspools. In Erith proper the houses are nearly all drained. At Abbey Wood, Belvidere, and Northumberland Heath the houses are not drained.

4454. (*Dr. de Chaumont.*) Did typhoid fever occur to any extent in houses that had cesspools?—In some cases. At Northumberland Heath, for instance, the year before last there was a family that had typhoid.

4455. Was the proportion of typhoid larger in the houses that had the tidal wells?—Yes, undoubtedly; but we have not had any typhoid for some few years.

4456. (*Mr. Balfour Browne.*) When you say that you have not had typhoid fever there for several years, of what place are you speaking?—I am speaking of the parish of Erith.

4457. (*Mr. Beaumont Morice.*) How long ago were most of these wells closed?—Last year we closed six or seven, and we have closed, I suppose, every year, more or less. I daresay we have closed six or seven wells almost annually for four or five years past at any rate.

4458. Do I correctly understand that those were nearer the river side than others?—They were.

4459. The upper part of Erith, you say, is healthy?—I say the whole of Erith is healthy.

4460. Do you still think that the sewage passing down the river is likely to exercise an evil effect?—I have not a doubt of it. I, myself, have been yachting. Only last summer I went out yachting and on returning with the flood tide there were large masses of sewage, as large as the table in front of me, floating about; and ladies on the yacht were sick and could not eat their tea on account of the atrocious smell from those masses of sewage that were floating about in the river; and that was on the flood tide, and not on the ebb. I may say, on the early flood tide.

4461. (*Chairman.*) Where were you then?—Off Purfleet.

4462. (*Mr. Beaumont Morice.*) That is just down at the bottom of Erith Rands?—Yes.

4463. That was on the flood tide, you say?—Yes, that was on the flood, about last July, which was a very hot month.

4464. Have you often noticed this on the river?—Yes, I have, and especially on the mud at low tide. You see the gases bubbling up through the mud at low tide constantly.

Cross-examined by Mr. Bidder.

4465. There is no doubt, is there, that the health of all Erith at the present time is exceptionally good?—It is good, certainly; I will not say exceptionally good.

4466. Is it not exceptionally good in this sense, that it is better than the average of London?—I think not. I think last year, if you look at the Registrar General's returns, you will find that the whole of England was very much healthier than it has been for years.

4467. I am not asking you about the whole of England; but is it not the fact that the statistics show that the health of Erith is better than the average health of London?

(*Chairman.*) That will appear by the Registrar General's returns.

(*Witness.*) I know that the last year's returns were lower; but last year was an exceptionally healthy year. You must remember that Erith is a country place, and not a town like London.

4468. (*Mr. Bidder.*) You said that one of the causes to which you attributed the healthiness of Erith was that it is a new place, to a great extent?—New cottages have been built.

4469. Are you aware that a large proportion of the houses of Erith do not drain into the river at all, but depend upon cesspools?—I am aware that in some part of Erith they do.

4470. Would you be surprised to hear that the surveyor has told us to-day that 507 houses drain into the river, and 1300 do not?—But you must look at the map of Erith itself in order to understand that. If you take the town of Erith proper, you will find that nearly the whole of the town of Erith drains into the sewers, but just the outskirts of the town, the branches you may say, do not. The 1300 refers to the houses in Belvidere and Northumberland Heath.

4471. Do you make annual reports?—I do.

4472. Do you happen to have your last annual report here?—I have it in my pocket.

4473. Will you produce it?—With pleasure, if you will hand it back to me again.

4474. (*Chairman.*) Is that the original?—This is a press copy of the original.

(*Chairman.*) We must have the original, and then it will be put in.

4475. (*Mr. Bidder to the witness.*) Is it the fact that the death rate of Erith has been decreasing year by year?—It has not.

4476. What is the death rate in the last completed year, 1881?—It was a very low rate, 114 deaths.

4477. What is that per 1000?—I do not know that I can calculate that out at a moment's notice. In 1878 there were 147 deaths; in 1879 there were 165 deaths; in 1880 there were 165 deaths; and in 1881 there were 114 deaths. There was a great fall in 1881, but in the two previous years there was an increase.

*Mr. F. B. Jessett.*

28 Nov. 1882.

4478. Will you tell the Commission, if you can, the death-rate per 1,000 in each of the last three years?—I do not know that I can do that. It so happens that the number is not down here. I have only the year 1880, when the death-rate was 14·63 per 1000.

4479. Did you officially report the death-rate in 1880 to be 14·63 per 1000?—I reported in 1880 that allowing for an increase in population according to the usual rate ——

4480. (*Chairman.*) Was this report in writing?—It was in writing.

4481. (*Mr. Bidder.*) Did you report the death-rate of 1880 to be 14·63 per 1000?

(*Chairman.*) That will appear from the written report.

4482. (*Mr. Bidder to the witness.*) You will be able to give me that report hereafter?—Yes. If I had had notice that the question would be put, I would have brought it with me, but I had no notice to bring these papers.

4483. Can you remember whether, according to your judgment, the death-rate of last year works out at less than 14·63 per 1000?—Last year it was 11·1 per 1,000.

4484. Has there been a remarkable absence of cases of death from diseases which would be attributable to causes such as sewage contamination?—There has been a great diminution in all deaths from infectious diseases or typhoid fever, because the sanitary arrangements of the place are very much better than they used to be.

4485. The deaths from typhoid are very few, are they not?—Very few. I think last year there were only one or two.

4486. The deaths from diarrhœa are very few, are they not?—I cannot remember straight off.

4487. And there have not been many deaths from diphtheria, have there?—There has been only one death from diphtheria to my knowledge.

4488. You have told the Commission, as I understand, that in the case of the wells that have been closed you are inclined to attribute their polluted condition to a percolation of sewage from the river?—I have promulgated that as my opinion some years ago; in fact I reported it to the local board as my opinion.

4489. What wells were closed last year?—I can tell you by looking at my report; but I cannot tell you straight off the reel.

4490. Were they not principally wells in the cottages behind West Street?—I do not think that well was closed. If my memory serves me rightly, I wished to have that well behind West Street closed, but it was not closed.

4491. Where were the wells that were closed; were they not in the same neighbourhood?—No, they were not; they were more in the High Street, if I remember rightly.

4492. Are they all in the neighbourhood of the river?—Yes, all except those in Belvidere: those in Belvidere were not in the neighbourhood of the river.

4493. Are not most of these wells in immediate contiguity to cesspools?—Not to my knowledge; not the ones in Erith proper.

4494. The well in West Street unquestionably was?—Yes, the well in West Street was, but that was not closed, although twice samples were sent to the public analyst.

4495. Were any others analysed by the public analyst?—All of them that have been closed.

4496. Have you the reports, or have the local board the reports of the public analyst?—I think there are reports upon all of them.

4497. Which could be produced?—I have no doubt they could.

The witness withdrew.

Mr. Richard Armitage called in, and examined by Mr. Beaumont Morice.

*Mr. R. Armitage.*

4498. You live at Woolwich?—Yes.

4499. What are you?—A fisherman.

4500. How long have you known the river?—I was apprenticed when I was 16 years old, and I am 66 now; that would be 50 years.

4501. Do you remember the outfalls being opened?—Yes, perfectly well.

4502. Is there any difference between the river now and what it used to be before the outfalls were opened?—A great difference, indeed.

4503. In what respect?—We could catch fish at Woolwich 50 years ago, or less than that. Twenty years ago there were plenty of fish at Woolwich.

4504. (*Chairman.*) Used you to catch fish 20 years ago there?—Yes.

(*Mr. Bidder.*) Many days ago, when Lord Bramwell was in the chair, I told my learned friend that I admitted that fish could be caught in that reach formerly and that they were not caught now, and we were told that that was an end of it.

(*Mr. Beaumont Morice.*) I know that the matter with regard to the fishing is done with. I am only going to ask the witness one question as to a date.

(*Chairman.*) I understand the admission to be that there used to be fishing up the river in the direction that the witness speaks of, and that now no fish can be caught there.

(*Mr. Bidder.*) That it used to be worth fishing, but that now it is not; I do not say that there are absolutely no fish.

4505. (*Chairman, to the witness.*) Practically, are there any fish above Gravesend?—No, we cannot get any fish above Gravesend.

4506. (*Mr. Bidder.*) It does not quite go so far as that; but practically for a considerable distance the river is not worth fishing?—Since the outfalls have been opened, there have been no fish. There are no fish this side of Gravesend. If they do come any higher up than Gravesend, they get killed by the sewage water.

(*Mr. Bidder.*) The last witness but one had been on a shrimping expedition at Grays.

4507. (*Mr. Beaumont Morice.*) And another tried to fish and got nothing.

(*To the witness.*) When did you find that you could not get any more fish in the old fishing grounds?—We have done no good in the way of fishing since the southern outfall has been built.

4508. (*Chairman.*) You have done no good there?—Not this side of Gravesend, not to get a good living, since the southern outfall was opened. We used to get a good living off Erith.

4509. (*Mr. Beaumont Morice.*) What is the state of the water at the present time down the river?—Very bad; very black indeed at certain times of the tide.

4510. Is there any smell or stench from it?—Yes, very bad indeed.

4511. You know the mud stuff along the banks, what is that like?—The settlements along the shore are quite black, and of a slimy nature.

4512. Is that only at one part, or does it extend away down?—At Long Reach it is very bad indeed; that is just above Greenhithe.

4513. Are there any other parts?—At Erith in particular; that is the worst place there is. There are solid banks of mud rising up there 7 or 8 feet high.

4514. Anywhere else up the river?—Yes; there is the northern outfall in what they call Gallion's Reach.

4515. Are there any more of the deposits of mud that you have been talking of further up than Erith Reach?—Oh, dear me; Yes.

4516. Where?—At Dagenham in particular.

4517. Then you say that all the way from Dagenham, round Erith, through Erith Bight, and down Long Reach there are these deposits?—Yes.

4518. Have they increased during the last few years?—Yes, they have increased very much indeed.

*Mr. R. Armitage.*
28 Nov. 1882.

4519. Is it ordinary mud, or what is it like?—What used to be bright mud is now quite black.

4520. Do you know how far anything will go down on the ebb tide if it is put in, say, at Crossness?—Yes; it might drive to Gravesend.

4521. Have you ever tried anything of the kind?—No, I have not; but I should judge that that is where it would drive to.

4522. Do you know whether the deposit stuff settles in the river, or whether it is carried down?—All the thickest of it settles along the shore, and nothing can live nigh it. It has killed all the red worms in the mud and all the bright worms; and there is no food for fish. If the fish came up they could not live.

4523. Do you know where it settles?—Yes; off Jenningtree Point and off Dagenham Docks.

4524. And all the way down the river?—From the northern outfall downwards.

Cross-examined by Mr. Bidder.

4525. You find no worms now in the mud?—No.

4526. No long worms that feed on rope or anything else?—No; there is nothing for them to eat now.

4527. If anybody says that they find long red worms in the mud of the river now they are talking nonsense?—That is wrong; there are none this side of the Lower Hope now. I have looked after them; in fact, we used to get them for bait at one time.

4528. And you cannot get them now?—We should be very glad to find them now.

4529. You used to fish above Gravesend?—Yes, but we cannot do so now.

4530. What did you get?—Shrimps, flounders, eels, and smelts.

4531. Where do you sell your eels?—I generally bring them to Erith.

4532. How do you take them?—In a corfe.

4533. You do not put them in the water?—No.

Examined by the Commission.

4534. (*Chairman.*) Have you ever tried any grappling in the mud?—Yes; occasionally we go grappling and dredging.

4535. In grappling you have never found any long worms?—No; if it is only a bit of rope, anything that we pick up on the grapnel is all black and slimy.

The witness withdrew.

Mr. James Adams called in, and examined by Mr. Beaumont Morice.

*Mr. J. Adams.*

4536. You live at Grays?—Yes.

4537. That is on the north shore?—Yes.

4538. And you are master of the barge C.T.F.?—Yes.

4539. How long have you known the Thames?—40 years and over.

4540. Will you tell us what difference there is in the state of the river, if any, between 30 years ago and now?—Yes, I can. Years ago, before the Crossness Outfall was built, I have seen ships lying just below there, colliers drawing from 14 to 15 feet of water.

(*Mr. Bidder.*) I have admitted long ago, formally, that banks have grown up at Crossness, and at Dagenham, and at Barking, which were the subject of the previous arbitration.

4541. (*Mr. Beaumont Morice to the witness.*) What is the condition of the river now?—There are not 5 feet of water.

4542. What kind of water is it?—Very bad indeed; filthy.

4543. In getting your anchor and chain up, do you find anything on it?—It is smothered with filth; there is nothing but sheer matter on it; it takes us half our time to sluice it with water to get the muck off it.

4544. Is there any smell about it?—Oh yes, enough to knock you backwards; dreadful.

4545. In going up and down the river have you ever noticed at what time the sewage comes out of the outfall?—At about half flood; about three hours before high water.

4546. (*Chairman.*) You have noticed that?—Yes, plenty of times.

4547. (*Mr. Beaumont Morice.*) Can you tell us, from your own knowledge, how far sewage coming out at half-flood would go up the river?—I should think it would go to Blackwall.

4548. Have you ever tried how far it would go up?—No; but we know by letting go our anchor, and getting our anchor, by the chain.

4549. Have you noticed whether this stuff in the river settles down, or whether it goes out to sea?—It goes away down.

4550. Where does it go to?—It would go as far as Long Reach, I should think, below Purfleet.

4551. Can you tell us how far it would come back on the flood?—I do not know that I could do that.

4552. Does this stuff affect the paint on the barges at all?—Yes; we frequently bring up at Crossness, which is an anchorage for us, and it turns the paint all manner of colours when we lie there, because we lie there seven hours ebb when we bring up at high water.

Cross-examined by Mr. Bidder.

4553. What is your business principally?—Carrying cement from Purfleet to the Docks and the Pool.

4554. When did you see the sewage coming out at half-flood?—I see it frequently; some two or three times a week.

4555. When did you last see it coming out at half-flood?—It was dark when we last came by; but we saw it about a fortnight ago.

4556. You saw it coming out at half-flood about a fortnight ago?—Yes.

4557. At what time in the day or night?—In the afternoon.

4558. Were you going up on the tide?—No, coming down.

4559. With your barge?—Yes.

4560. And you saw the sewage coming out?—Yes.

4561. What sort of barge is yours?—She will carry 80 tons.

4562. Is it a rowing or a sailing barge?—A sailing barge.

4563. Are you accustomed to come down then on the flood tide?—Yes; we come down at all hours of the night and day, just as the tide suits.

4564. The tide would not suit if it were half-flood, would it?—We come over the tide with a fair wind frequently.

4565. Where were you coming from?—We were coming from Beckton.

4566. Would you mind fixing a little more definitely what time of day it was?—I should think it was about 3 o'clock in the afternoon, but I would not be sure.

4567. Do you recollect at what time it was high water that day?—I almost forget now about what time it was. I could refer back and see if I had an almanac.

4568. What did you see on that occasion?—It seemed like nothing but grease.

4569. Where?—I should think 100 yards away all round from the sewer where it comes out.

4570. Did you look at the outfall itself?—Yes; we could see the pumping out; we could see it coming right out.

4571. In large quantities?—In large quantities; it would take your barge away from your helm.

4572. You say that this was at half-flood?—Yes.

4573. And about a fortnight ago?—Yes.

4574. (*Mr. Beaumont Morice.*) That is not the only time you have seen it?—No; I have seen it more than once.

4575. (*Mr. Bidder.*) Do you know the sewer at Beckton?—Yes.

4576. Have you ever seen anything going out of that?—Yes. It is in a frightful state; it is just as bad off the sewer there as it is in Half-way Reach.

4577. Is the stuff that comes from that sewer offensive?—Yes; if you let go your anchor it is just the same as it is at Crossness.

4578. (*Chairman.*) What do you mean by Beckton?—The gasworks, just below where the sewer is.

4579. (*Mr. Bidder.*) You have seen the stuff coming from the sewer?—Yes.

4580. And it is offensive?—Yes.

4581. Does it come in considerable quantities?—Yes, and it is just as bad as it is at Crossness.

4582. (*Chairman.*) Do you say that there is a sewer at Beckton?—Yes, a pumping station; it comes out of there.

4583. At Beckton?—Just below Beckton.

4584. (*Mr. Bidder.*) You are speaking of the northern outfall?—Yes.

4585. Do you know the Beckton Gasworks?—Yes.

4586. Do you know the sewer pipe that comes out there?—I never noticed it.

The witness withdrew.

Mr. Thomas Brown called in, and examined by Mr. Beaumont Morice.



4587. Do you live at Gravesend?—Yes.

4588. And I think you are the master of one of Messrs. Knight, Bevan, and Co.'s barges?—Yes.

4589. How long have you known the River Thames?—Forty-four years I have been master of a barge running from Northfleet to London.

4590. Do you remember the outfalls being made?—Yes.

4591. Can you tell us if there has been any difference in the state of the river between what it was before that time and what it has been since?—I know that ships lay afloat in 12 to 13 feet of water in Half-way Reach where I cannot now lie afloat with my barge.

4592. What is the state of the water itself?—It is in a most filthy state; nothing but impure matter. My cable and the anchor when I heave it up are blacker than my clothes.

4593. Where are you talking about now?—Half-way Reach.

4594. Do you find this impure matter and filthy stuff in other parts of the river as well?—In Erith Reach as well.

4595. What is the colour of the water?—As black as ink.

4596. Is there any smell to it?—Yes; enough to knock you down when they let the water out of the sewer.

4597. When have you noticed the sewage coming out of the outfall?—Two hours before high water in Half-way Reach.

4598. Have you noticed that more than once?—Scores of times. As soon as we come from Beckton with coke we catch it there, as it comes out, and it slews my barge all on one side.

4599. Is there any alteration in the colour of the water in the river when it comes out?—Yes.

4600. What is it like then?—It is nothing but a body of grease at the top, and underneath it is quite black, of a different colour altogether from the other water.

4601. Can you trace that down the river at all?—I have traced it down as far as below Erith.

4602. Have you ever followed it down on the top of the ebb?—That is when we very often come down, and sometimes we are two or three hours before high water, and it will follow us down, looking as black as my clothes.

4603. Have you ever started at the top of high water and gone with it as far as it went?—No, because we have no occasion to go any farther than our destination.

4604. You have gone as far as where?—To the Northfleet works, Messrs. Knight and Bevan's.

4605. Have you traced the sewage there?—No; I do not find a great deal in Northfleet Hope, not at the anchorage.

4606. Do you know the banks of the river all up and down on the south shore?—Yes.

4607. What is the stuff that is deposited there like in popular language; is it mud?—It is nothing but stinking filthy matter.

Cross-examined by Mr. Bidder.

4608. You apply that description, as I understand, to the mud off Crossness?—I apply it to what comes from the common sewer which causes this matter to be lying in the bottom of the river.

4609. Do you mean off Crossness amongst other places?—What was in Barking Shelf might come from the north side.

4610. When you describe the mud in that way, you are speaking of the mud that is in Half-way Reach off Crossness?—There is not such a great deal of mud there now, because just as you go below the creek in Half-way Reach it is all stonework; the wall is all stone.

4611. Where you used to have a great deal of water you now anchor, and you find that there is a great deal of mud and it comes up filthy on your anchor; that is off Crossness, is it not?—Yes.

4612. And you describe that mud as being what you said?—Yes, I do.

4613. What kind of barge is yours?—A 90 ton barge.

4614. Is it a rowing or sailing barge?—A sailing barge.

4615. Is it your business frequently to go down to Beckton with coke?—We load from there every freight.

4616. Have you noticed a sewer pipe at Beckton?—No; there is an outfall there.

4617. Did you ever see anything coming out of it?—Yes, but it is clear water; it is clearish water.

4618. Have you ever smelt anything coming from it?—Well, I cannot say that it is altogether sweet.

4619. Is it offensive?—It is not very pleasant.

4620. What sort of a smell is it?—It is not so bad as the sewer.

4621. "Comparisons are *odorous*" they say; but what sort of smell is it?—I cannot exactly tell you what sort of smell it is; it is not very pleasant.

4622. What sort of colour is the water that comes from it?—It is rather a muddy colour; there are no settlings in it. The water that comes from there is clear, but it is a kind of yellowish colour.

4623. Have you seen it lately?—Not the last fortnight.

4624. This summer?—Yes.

4625. Often?—Yes, and last summer.

4626. And you have complained of it, I daresay?—We must not complain of such things as those.

4627. You said, as I understand, that not long ago you went down with a cargo of coke and saw the sewage coming out of the Barking Outfall?—No; in Half-way Reach.

4628. Was it the Crossness Outfall?—Yes.

4629. How long ago was that?—It would be a fortnight ago to-morrow.

*Mr. T. Broum.*

28 Nov. 1882.

4630. That would be the 15th of November. What time in the day was it?—That was in the night.

4631. What time in the night?—About 11 o'clock, I think.

4632. You saw the sewage coming out of the outfall?—It will tell you itself when it comes out, because it throws the barge on one side by the force of it.

4633. Did you see it coming out of the outfall?—I could tell that it was running out.

4634. Did you see it coming out of the outfall?—Yes.

4635. There was no moonlight, if I remember rightly, a fortnight ago?—No.

4636. Do you know at what time it was high water?—About 1 o'clock.

Re-examined by Mr. Beaumont Morice.

4637. You say that you know by its slewing the barge round?—Yes; it is so strong when it comes out that we have to put the rudder over to port to keep her straight.

4638. Why do you not complain of such things as these?—It is not in my power.

4639. But it is not because you do not smell them?—No.

4640. What do you mean by saying that the water from this pipe at Beckton is clear, but yellow?—It goes through some process before it comes out into the river, and that turns the water a different colour. It comes from the tar or something.

4641. You say it is of a yellow colour, but clear?—Yes, there is nothing in it that I can see.

4642. What do you mean by saying that there is nothing in it?—No settlings.

Examined by the Commission.

4643. (*Chairman.*) You said that you could tell that sewage was coming out because it slewed your barge?—Yes; it comes out with such force.

4644. Then it was because your barge was slewed that you knew it was coming out, and not that you actually saw it coming out?—No; the pipes are under water. I cannot see it, but I can tell by the water.

4645. You supposed that it must be that because you felt your barge slew round?—Yes.

(*Mr. Bidder.*) It may interest the Commission to know that it was close upon dead low water at the time the witness mentions.

4646. (*Chairman to the witness.*) Was this at Crossness or at Barking?—I cannot tell you that. If I had known that I should have been asked these questions I might have brought my notes from the office.

4647. You are sure that it was a fortnight ago to-morrow?—No, I am not certain, because we do not take any notice of particular dates; but if I had known it I might have got my notes.

4648. (*Dr. Stevenson.*) What is the difference between the tide there and at London Bridge. If it was low water at half-past 4 at London Bridge, at what time would it be low water at the point you mentioned?—There would be about 40 minutes difference, I should think.

(*Mr. Bidder.*) There would be about half-an-hour's difference.

4649. (*Mr. Beaumont Morice to the witness.*) You are going up and down continually?—Yes.

The witness withdrew.

Mr. Robert Plumb called in, and examined by Mr. Beaumont Morice.

*Mr. R. Plumb.*

4650. You live at Gravesend, I think?—Yes.

4651. How long have you known the River Thames?—About 47 years. I am 57 years old, and I was at work with my father when I was 10 years old.

4652. During those 47 years has the river improved in its condition?—Well, we have to go further away after the fish.

4653. At what time did you have to remove further down the river for your fish?—Some 12 or 14 years ago, as nearly as I can remember. We used to go up to the top of Long Reach, and stand with what we called a sprat net, after eels. That was when we used to go up there. There used to be plenty of eels then up at the top of Long Reach.

4654. (*Chairman.*) Did you fish for them 14 years ago?—Yes. When the dead tides used to be the water was pretty middling, so that the eels would be between the two waters. As soon as the spring tides began to come, then down came the bad water, and we could not get any more eels, and we used to have to sweep them out of the wells to save their lives.

4655. (*Mr. Beaumont Morice.*) How many years ago is that?—That is 12 or 14 years ago.

4656. Can you tell us which is the stronger of the two tides, the flood tide or the ebb tide?—The ebb tide, I fancy, because there is more slack water on the flood tide round the points.

4657. Have you ever seen yourself how far anything would go down the river on the ebb tide, supposing you put it in at Crossness?—We know by the drive of the gear. I can go by where I drive with the tide.

4658. You have never tried yourself how far you would go down with the tide?—Only by the drive of the gear. We drive with the tide with a trawl overboard, and we can drive from Gravesend to about Leigh Middle; but then there is no tide on the bottom, scarcely.

4659. Is there any difference between the flood and the ebb as to the strength of the tide at the top and the bottom?—I do not think there is much. There is more slack at the top of the tide on the flood round the points than there is on the ebb.

4660. Where do you fish and get shrimps now?—Mostly in Sea Reach. Sometimes we have got a few in Gravesend Reach this summer, but very few. Sometimes we go down to where the Cutter in the Hope is.

4661. You get them in Sea Reach?—Yes.

4662. Have you to do anything with them before bringing them up to Gravesend?—We boil them.

4663. Why do you boil them?—Because we cannot keep them alive.

4664. Could you keep them alive in the water?—At one time of day I have laid off Gravesend with 20 gallons in the well all night.

4665. Why can not you keep them alive in the water?—Because as soon as you shoot them in the well now down they go, and they never rise any more, because the water is so bad.

Cross-examined by Mr. Bidder.

4666. I suppose you do not know the reason of their dying?—I know that the water is bad.

4667. How do you fix the 14 years which you have given us?—I say 12 or 14 years.

4668. How do you fix it?—I do not know what you mean by "fixing it."

4669. What makes you able to say that it is 12 or 14 years?—I know it is. You do not think I am such a dunce as not to know that.

4670. I have not said so yet?—I know it by the time that I have been on the water.

4671. You have been 47 years on the water?—

Yes; I have got boats of my own, and I know when I bought them and how old they are.

4672. You are more than 14 years old?—Well, I rather think I am.

4673. I understand you to say that you used at one time to catch them at the top of Long Reach, and that now you go further down. Are the fish brought up in the water now?—You cannot keep them alive as far as Gravesend.

4674. Nothing will live beyond Gravesend?—No.

4675. You never heard of the eel boats going up with the eels in the water?—They used to at one time of day, but they take the eels up in boxes in the boat now from Hole Haven; they would not live in the water.

4676. You have seen that?—Yes; always for these several years; I do not know how many years; ever since they have been down at Hole Haven.

The witness withdrew.

Mr. George Martin called in, and examined by Mr. Beaumont Morice.



4677. I believe you live at Gravesend?—Yes.

4678. I believe you are a free waterman?—Yes.

4679. How long have you been on the river?—Ever since I was 10 years of age.

4680. For about 40 or 50 years, I suppose?—I am now between 57 and 58 years old. I was born in 1824.

4681. You have known the river for nearly 50 years?—Yes.

4682. Do you remember the outfalls being opened?—Yes.

4683. Is there any difference between the state of the river now and what it was then?—Yes, very much.

4684. In what way?—I remember when we could well drink the water of the river at any time of the tide previously to these outfalls being opened.

4685. (*Chairman.*) At Gravesend?—No, in Halfway Reach and Barking and along the river. We used, when I was a hatch-boat boy, carrying the fish out of the smacks, to fill our water cask up there.

4686. (*Mr. Beaumont Morice.*) That you have not been able to do for some time?—No, not since the outfalls have been opened.

4687. Is there any alteration in the state of the river?—It very much fills up with mud and slush and muck, and it is in a filthy state.

4688. Is there any smell?—It stinks filthy.

4689. And is the stuff, which you say is on the banks of the river, mud, or what is it?—I do not know what to call it; it does not look like mud; it looks more like filthy muck.

4690. Has there been any alteration in that in the last few years?—It is very bad compared to what it was some few years ago; it is quite a filthy stench.

4691. Have you ever noticed when the sewage is coming out of the outfalls?—I have never seen one of the outfalls opened but once since I have been up and down the river, and that has been on high water, or sometime just before high water; and then I know the stench of it was something horrid.

4692. Is there any difference in the colour of the water?—It is as black as a coal.

4693. Have you been able to trace how far it goes down the river?—I have never known how far it goes down?—I have smelt it about as far down as Erith and Long Reach.

4694. Can you tell us how far anything goes down on the ebb tide if it is put in at Crossness?—I should think, according to my own mind, to about Gravesend Reach.

4695. Have you ever tried anything which would show that?—No, I have never had an opportunity of doing that.

4696. Do you know the fishing that takes place by Gravesend now?—I know but very little about fishing. I have never been in the habit of catching fish I have been in the habit of carrying many fish.

4697. Where do you carry them principally?—From Gravesend to Billingsgate.

4698. (*Chairman.*) Do you do that now?—Yes; I come up with fishing smacks from Gravesend, where I take charge as waterman down to Billingsgate.

4699. (*Mr. Beaumont Morice.*) How long have you carried them up from Gravesend in that way?—I should suppose about 38 years and over.

4700. Have you ever tried to bring the fish up in the well of a boat?—I have seen them brought up in what they call corves; things which are made like a boat full of holes on purpose to keep them in, like a trunk; but that is some years ago.

4701. How many years ago?—I suppose it would be 16 or 17 years ago.

4702. Is that done now?—No.

4703. Are you quite sure about that?—I am positive.

4704. Can you tell us why it is not done?—On account of the water; the fish would not live, the water is so bad; but I have noticed up as far as Greenwich that the water has been very good there lately, I suppose on account of the fresh water.

4705. That is in the upper part?—Yes, but below that it is very bad.

4706. Can you tell us whether below that it has been getting better or worse lately?—Really I could not tell you that; but I know it is very bad from Halfway Reach down to Erith and Purfleet.

4707. Can you tell us whether it makes any difference to a fisherman sending fish up by water or by rail?—I should imagine that it did, because I remember that some few years ago they used to bring fish to Gravesend and they used to be in the well for two or three days; but now they cannot do so.

4708. Do you know whether it is more expensive to send fish up by rail?—Yes, a deal more expense.

Cross-examined by Mr. Bidder.

4709. Do I rightly understand that you have been for 38 years engaged in taking fish from Gravesend to Billingsgate?—Yes.

4710. In your boat?—No, in a fishing cutter. They go to the North Sea, and they have the fish put into the vessels there, out of the vessels that catch them.

4711. Are you still engaged in that business?—No.

4712. Are those fish alive?—No, they are all dead and packed.

4713. They are dead long before they get to Gravesend?—Yes.

4714. And they are brought up in the hold of the vessel?—Yes.

4715. You are not a fisherman?—No, I am a waterman.

4716. You have nothing to do with the live fish?—No.

4717. When you said that the river was very bad from Halfway Reach to Gravesend, what is it exactly that you had in your mind?—No more than that the water is bad and smells beastly; that is all that I have in my mind, and I could prove it.

4718. The Commissioners could go and smell it all the way down to Half-way Reach?—I believe they could.

4719. As far as Gravesend?—No, I do not say that; I say as far as Long Reach.

4720. You say that the fish will not live if they are

*Mr. G. Martin.*

28 Nov. 1882.

brought up to Billingsgate in corves now?—I do not believe they would.

4721. Eels would not live?—Yes, and I will tell you how they live. They bring them through Halfway Reach with a tug, and directly they get above Halfway Reach or to Greenwich they have the water pure. They are in the wells on board the vessels.

4722. (*Chairman.*) So that they get the river water there?—Yes, they get by Halfway Reach as quickly as possible, on the low water if they can, and then they get clear of that water that is so bad.

4723. But they do come through Halfway Reach and carry them up to Billingsgate at the present time?—Yes.

4724. (*Mr. Bidder.*) And they come up alive?—Yes.

4725. And that has been done very lately?—Yes.

4726. (*Mr. Abernethy.*) Is that a common way of bringing fish up?—Eels in particular.

4727. (*Colonel Ewart.*) Would that be done in summer?—I believe so.

4728. (*Mr. Balfour Browne.*) Have you seen it done?—Yes, I have, or else I could not say so.

4729. (*Chairman.*) What did you say about their coming up at low water?—If they can get by there at low water, before any of this stuff is poked out, as I term it, they do not feel the effect of it as they would if it came out on high water. I have known it push boats on one side when it has been coming out.

The witness withdrew.

Mr. John Tall called in, and examined by Mr. Beaumont Morice.

*Mr. J. Tall.*

4730. You live at Gravesend, I think?—Yes.

4731. And you are a waterman and lighterman?—Yes.

4732. How long have you been on the river?—About 36 years.

4733. You remember when the outfalls were made?—Yes, well.

4734. Has there been any difference between the state of the river before and since?—A great deal.

4735. In what way?—It is worse, a great deal.

4736. What is the river like now?—It is dirty, filthy, black mud.

4737. Is that at one particular part or at different parts?—Between Erith and Woolwich, principally.

4738. Can you tell us what it is like?—The mud is thick black mud.

4739. Is it like ordinary mud; is there anything that you can tell it by?—You can tell when you get into where the drainage is by the chain that you ride by.

4740. How can you tell it?—Because it turns the chain black.

4741. Is there any smell to it?—Yes, it stinks very much; it has a very nasty smell.

4742. Have you been up the river at any time when the sewage has been coming out?—Yes, a great many times.

4743. Have you noticed what time of the tide it has been coming out?—I have not taken notice of any particular time. I have never passed it without seeing it coming out.

4744. Can you give us from your memory what time of the tide it was when you saw it coming out?—I have been in the habit of passing it at all times of the tide. I have been up and down the river six times a week; so that I have occasion to pass there a great many times.

4745. Have you noticed the mud and stuff up and down the banks of the river?—On the shores.

4746. What is that like?—It is a soft slough stuff.

4747. Is it mud?—It is more like slime.

4748. Is there any smell from that?—Yes.

4749. Has it been increasing lately?—It has been increasing fast.

Cross-examined by Mr. Bidder.

4750. The smell or the mud?—The mud.

4751. In Halfway Reach?—Yes.

The witness withdrew.

(*Mr. Bidder.*) You will understand that although I do not ask this gentleman any questions upon his evidence as to the mud, I do not admit that it is correct.

Mr. William Brown called in, and examined by Mr. Beaumont Morice.

*Mr. W. Brown.*

4752. You live at Gravesend, I think?—Yes.

4753. And you are a fisherman?—Yes.

4754. How long have you known the river?—56 years. I have been master of a little fishing boat.

4755. Do you remember the outfalls being made at Barking and Crossness?—I do perfectly well; but I cannot tell you how long ago it is.

4756. Has there been any alteration in the state of the water since the outfalls were made?—A wonderful sight of difference.

4757. (*Chairman.*) For better or for worse?—For worse.

4758. In what respect?—As far as my knowledge goes, we could get a living in the winter seasons.

4759. But how is the river worse?—Because nothing in the world will go up into it to breed.

4760. But what is the matter with the river?—That is a question I cannot answer, because I cannot tell what goes into it.

4761. You say it is worse?—It must be if nothing will live in it.

4762. It does not look worse, does it?—You cannot see it on the top so much.

4763. Is it the ordinary colour?—When it is hot weather you can see a difference.

4764. Is the water the same colour as it used to be?—I do not know that I can exactly say.

4765. Has it the same smell as it used to have?—I do not know that it ever had a smell.

4766. Has it a smell?—Not to my knowledge. I have not been up the river above Greenhithe for some time.

The witness withdrew.

Mr. Henry Evans called in, and examined by Mr. Beaumont Morice.

*Mr. H. Evans.*

4767. You live at Woolwich, I think?—Yes.

4768. What are you?—I am an under-waterman and sand dredger.

4769. How long have you been there?—All my life.

4770. Do you remember the outfalls being opened?—Yes.

4771. Has there been any difference in the state of the river since that time?—A vast deal.

4772. In what way?—In regard to the refuse and

rubbish at the bottom of the river, and likewise the sand that we dredge, sometimes with dredging irons and sometimes with a shovel. At Jenningtree Point, which I used to frequent nearly every day in the week 30 years back, the sand was always very good and clear, but of late years it has been very filthy and dark. There was a kind of streak of sand and then a streak of greasy black mud, and it was scarcely any use to us; and in warm weather we could scarcely stand to our tools to work it for the stench and the refuse under the bottom of the sand.

4773. Have you been up and down the river much?—Ever since I was a boy, two or three times a week.

4774. Can you tell us at all whether you ever noticed when the sewage comes out of the outfalls?—Yes, at the southern outfall in particular. I have been rowing down from Woolwich, say, two hours before high water, and when I have got down about Barking Creek round by Tripcock Point I have seen the water coming up when it has been blowing a little breeze, a little roughish on one side and the other side smooth, and it was the stuff lying on the water that caused the smoothness. It was broken water on the north side, and on the south side it would not break. We always work up this greasy water because it is smooth water.

4775. And you have noticed that more than once?—Frequently I have noticed it come out two hours before high water.

4776. How often do you go up the river?—Sometimes four, sometimes three times a week, and sometimes every day in the week, according to what we have to do.

Cross-examined by Mr. Bidder.

4777. You have been going down the river, and you have noticed that one side of the river was roughened by the wind and the other side was smooth?—Yes, at times.

4778. And you attributed that to the greasiness which came from the sewers?—Yes.

4779. And you inferred from that that the sewage was coming out?—I have been there when the current from the sewage has driven my boat away.

4780. What sewage?—The sewage from the southern outfall.

4781. You told my learned friend that this was at half flood?—Two hours flood. It takes me half an hour to row down from Barking Creek to Woolwich; it would be about an hour and a half's flood by the time I got to Barking.

4782. And then, seeing the greasiness made you believe that the sewage was coming from Crossness?—Yes, because I never found it before the outfalls were built

4783. (*Chairman.*) Have you ever perceived any smell in the river?—Yes.

4784. What kind of smell?—Very bad; it is a very sickly smell, especially by Barking Creek up to what you call the northern outfall.

The witness withdrew.

(*Mr. Beaumont Morice.*) Bearing in mind what I mentioned at the commencement of the sitting, perhaps the Commission might like to hear some statement from me as to the course which I propose to take. I have a very large number of witnesses; I do not say that they are all exactly like those that have been called to-day, but some of them are persons resident in the locality, and others are actually connected with the river. The further evidence that I can bring forward on behalf of the memorialists will to a great extent be on the same lines as that which I have already put before the Commission. I admit that to a large extent it has been repetition, and I have felt that the Commission have been very kind to listen to it; but of course the essence of my case here is that the evil is widespread, and is felt by a large number of persons. Beyond that, I, on behalf of the memorialists, am not prepared to go. With regard to the chemical evidence and matters of a more abstruse kind, that of course will involve a large expenditure of money, which the memorialists have not been able to undertake, and those questions I believe will be dealt with by my learned friends who represent the City authorities. That being so, I would wish to leave the matter in the hands of the Commission. Perhaps by my formally tendering a large body of evidence which I have still remaining, not wishing thereby to be considered as closing my case simply upon that evidence which I have brought before you, the Commission might see their way to throw out some intimation to me with regard to the desirability of having some further evidence upon any point.

(*Mr. Bidder.*) You will hardly ask the Commission to commit themselves to any opinion upon the point.

(*Mr. Beaumont Morice.*) I do not ask them to commit themselves.

*The Commission deliberated.*

(*Chairman.*) The feeling of the Commission, Mr. Morice, is that a continuance of this kind of evidence would not strengthen your case in any way. If hereafter the evidence of these people should be seriously contested; if it should be shown that there are no grounds for holding that the river is unpleasant to those who are upon it, not as a question of healtht but simply as a question of comfort, we should, no doubt, give you an opportunity of calling further evidence; but to go on heaping witness upon witness upon the same point would not, I think, strengthen the case which you have at present made. It will now be for your adversaries to deal with it, and if that case should be shaken you shall have an opportunity of calling further evidence.

(*Mr. Beaumont Morice.*) I am much obliged to you, sir. That is all I wish for in the matter. I have a large body of evidence, not only of witnesses similar to those whom I have called, but of persons in a different position of life; but I am quite satisfied with the intimation you have given, and therefore I will reserve myself.

(*Mr. Bidder.*) I think it is right that I should say at once that it will be strongly contested, in the evidence that I shall call, that the state of the river is such as to seriously interfere with the comfort of the people living or trading on the river. It seems to me, as I intimate to my learned friend now, that if there is any further evidence to be got upon that point, which is material, now is the time to bring it forward, because then I know what case I have to meet, although, if I may respectfully say so, I entirely endorse the views of the Commission that merely repeating witness after witness of the same kind does not add to the strength of the case. I am willing that it should be taken as assumed, as I have no doubt is the case, that my learned friend could call 20 or 30 or 50 more witnesses who would, with the same sincerity of belief, give practically the same evidence as those who have already been called; but I confess that I should like to hear the whole indictment against me, because I am put on my defence.

(*Chairman.*) With respect to what has fallen from Mr. Bidder as to its being an indictment, the fact is, we are here merely as a court of inquiry. Mr. Bidder's clients are not upon their defence. We are all engaged in one common cause, and every witness that Mr. Morice calls is Mr. Bidder's witness, and every witness that Mr. Bidder calls is Mr. Morice's witness.

*Mr. H. Evans.*
28 Nov. 1882.

We must look upon it in that light. But I still think that the feeling of the Commission is that you, Mr. Morice, have started a sufficient *primâ facie* case. If it should be shown that your witnesses are really mistaken, or that they are misleading us, we shall give you the opportunity of calling any further evidence that you may think necessary.

(*Mr. Beaumont Morice.*) I am much obliged to you, sir. That is all that I wish for.

(*Mr. Bidder.*) I presume, of course, that the Commission will extend the same privilege to me.

(*Chairman.*) Of course.

(*Mr. Beaumont Morice.*) We made an application that the quantities of sewage discharged by the Metropolitan Board from their outfalls should be given to us. We have written for them, but we have not been able to obtain them.

(*Mr. Bidder.*) My learned friend can get them in the proceedings of the last arbitration, of which your secretary has a copy. All that information will be found in print, given most carefully and exactly.

(*Mr. Lumley Smith.*) If there is any doubt about it, we can refer to the notes. It was distinctly promised us by Sir Joseph Bazalgette. He said that it would take a little time to get out, but that the figures were to be sent to us, and we hope to get them.

(*Mr. Bidder.*) Anything that Sir Joseph Bazalgette has promised I am quite sure he will supply. I am told that the explanation is, that it was asked to be furnished on the 12th of December, and it was promised that it should be ready then.

Adjourned to to-morrow at half-past 12 o'clock.

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# NINTH DAY

## Wednesday 29th November 1882.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ. F.R.S.E. Mem. Inst. C.E.

W. POLE, ESQ., F.RS., *Secretary.*

(*Chairman.*) There is one little correction that I would wish to make with respect to what I stated yesterday about your calling further witnesses, Mr. Morice. If we should desire to hear any further evidence of that kind you will give us the names of any persons who you think can throw light upon this case, and we will examine them ourselves.

(*Mr. Beaumont Morice.*) If you please. There would be no limit as to any number, I suppose. Of course if the Commission give an intimation to that effect, I shall be able to call a good many more witnesses.

(*Chairman.*) Fifty witnesses have told us certain facts, and we might get 500 more to say that they concur in the views laid before us by those 50.

(*Mr. Beaumont Morice.*) I will bear that in mind.

(*Mr. Lumley Smith.*) I appear with my learned friends Mr. Webster and Mr. Balfour Browne for the Corporation of the City of London; and the first gentleman that I propose to tender to the Commission is a gentleman who would to some extent give similar evidence to what has been given before, that is to say, general evidence. But he is a gentleman of a totally different class to those you have heard. He is the vicar of St. Nicholas, Plumstead, and he has taken a good deal of interest in this matter, and seen what he considers to be the effect in his parish; and he is a witness whom the Commission would probably like to hear. With your permission, sir, I will put him in the chair.

The REV. JOHN MCALLISTER called in; examined by Mr. LUMLEY SMITH.

*Rev. J. McAllister.*
29 Nov. 1882.

4785. I believe you are the vicar of St. Nicholas, Plumstead?—Yes. St. Nicholas, Plumstead, is the east end of Plumstead, containing a population of about 15,000.

4786. And you reside at Heathfield, on Plumstead Common?—I do.

4787. How many years have you resided in that parish?—Nineteen years.

4788. Could you point out to the Commission on the map where Plumstead is?—Plumstead is between Woolwich and Erith (*pointing it out*).

4789. And it is to a certain extent off the river?—Yes.

4790. Does the parish go down to the river?—Yes, the north boundary of the parish is the river.

4791. To what extent does it border the river?—About 2 miles.

4792. About 2 miles of the parish is co-terminous with the river?—Yes.

4793. Do your pursuits take you much to the river; do you go on the river?—I am in the habit of going on the river frequently, and by the river.

4794. I believe that you have paid some attention to this question of how far the Thames has been affected by sewage?—As an amateur I have.

4795. Have you on occasions noticed sewage in the river?—Yes, frequently.

4796. Of what parts of the river are you now speaking; are you speaking of the part co-terminous with your parish?—More especially co-terminous with the parish; but in going up and down the river I have seen sewage both above and below.

4797. Has it been going up or going down, or stationary?—Sometimes going up, and sometimes going down.

4798. Your parish is above the outfalls, I understand?—It lies between the mouths of the two outfalls.

4799. When sewage has been going up, I presume the tide must have been flowing up?—Yes, it has been carried up by the tide. I noticed that.

4800. Has that been a matter of frequent occurrence or an exceptional matter, that you have seen sewage going up the river?—I have seen it frequently going

up the river. I could not say that it is an exceptional kind of thing; and sometimes at a time when I should have expected it to have been going the other way.

4801. What do you mean by saying that you have seen it at a time when you would have expected it to have been going the other way?—I always understood that the rule was only to open the sluices at the time when the tide was flowing towards the sea; but I have noticed the sewage floating up t such a time as the sluices must have been shut.

4802. At any rate it was floating up. Have you seen deposits on the sides of the banks?—Yes, frequently.

4803. Have you examined the deposit to see what it was?—I have carefully.

4804. What have you found?—A mass of worms.

4805. What is the character of the deposit?—Evidently human excrement in a state of decomposition.

4806. And breeding living creatures?—Full of them.

4807. Has this deposit any smell?—Yes, a very offensive smell, particularly in the summer season of the year.

4808. Passing from the smell of the mud when you examined it, have you in Plumstead experienced any smell which you attribute to the sewage?—Yes, very often.

4809. (*Chairman.*) Where have you experienced this smell?—All over the parish, a distance of 3 or 4 miles from the river it is very offensive indeed.

4810. (*Sir John Coode.*) Do you think you could discriminate this as being the smell of sewage, at a distance of 3 or 4 miles?—Most easily.

4811. You know that it is not from any of the chemical factories?—I can distinguish the smell from the chemical factories from the other smell as easily as I can the smell of an onion from the smell of boiled cabbage.

4812. And you think that you can detect the sewage smell at a distance of 3 miles from the river, is that so?—Certainly.

4813. (*Mr. Lumley Smith.*) I am afraid you have a good many bad smells in the neighbourhood, but this is perceptibly distinct from the other smells?—Yes, quite distinct.

4814. At what seasons do you find this smell most?—The seasons when we feel it most are the seasons when the north-east wind blows, about the month of March; from the middle of March on to the middle of April, in the early part of the year; then in the autumn from about the middle of September to the end of October. Those are the worst seasons, arising in a measure from the fact that the north-east wind is more prevalent then than at any other time.

4815. Is this smell sufficiently strong to be disagreeable?—It is very disagreeable indeed

4816. Is it a strong smell or a weak smell?—Very strong indeed.

4817. I suppose you visit a good deal amongst all the inhabitants of your parish. I am not treating you as a medical man, but do you find that the health of your parish has been affected at all by the sewage?—I have taken particular interest in noting that, and at certain seasons when these foul odours came over the parish I have noticed that the effect produced upon the health of the inhabitants is much the same as the effect that a hot wind would have on vegetable life if it were blown over vegetable life under certain conditions; that is to say, that the *vis vitæ* sinks directly; and you find that the inhabitants, as a rule, myself included, feel it. I am as healthy a man perhaps as you would find anywhere, but I feel it as others do; that the vitality is not as powerful in the animal system as it is at other times; and I have spoken to some very intelligent medical men about it.

(*Mr. Bidder.*) We must not have what they said.

4818. (*Chairman.*) Within your own personal experience, you have felt that your vitality is not as powerful when under the influence of these smells, as it is at other times?—Yes.

4819. (*Mr. Lumley Smith.*) My learned friend desires that you should not tell us what the views of the medical men were; but however, that is your opinion about it?—Certainly.

4820. Does the effect amount to actual disease, or merely to this diminution of the *vis vitæ* which you have spoken of?—That is a question that I should not like to speak positively upon. During the 19 years that I have been at Plumstead I have had scarlet fever in my own family three times, and I have lost two of my children by it, and, of course, I have my own opinion as to the cause of it; but as I have not been able to trace it positively and distinctly, I should object to commit myself to any positive opinion upon the subject; I mean as to this sewage being the direct cause of disease.

4821. But as to the influence on the vitality of your parishioners, you have an opinion, and that is the opinion you have given us; is that so?—Quite so.

Cross-examined by Mr. Michael.

4822. Could you tell me precisely any dates when you have noticed the sewage floating up?—No, I could not give you any dates; I have not taken any particular notice of that; it has occurred so frequently.

4823. Would you tell me the last time that you saw it?—Last summer.

4824. What part of the summer?—In the months of June and July.

4825. Where were you at that time?—On the river and by the river

4826. On the river itself?—Yes.

4827. What was it that you noticed? What was it that to your mind precised that it was sewage that you saw floating?—I saw black greasy matter, conveying to one's mind much the same impression as if you poured a small stream of ketchup into a basin of ordinary brown soup, having much the same effect upon the water as the ketchup would have upon the soup.

4828. Then you saw ketchup and water, or something of that colour, floating upwards; is that what I am to understand?—Sometimes floating up and sometimes floating down.

4829. Were you able to trace where it came from? How far did you see it come?—I cannot say how far.

4830. Where were you situated?—I have been on the banks of the river at times.

4831. But would you kindly tell me where, because I understand that your parish is partly between the two outfalls; were you standing between the two outfalls when you saw this?—Yes.

4832. At what time of the tide was it?—Sometimes when the tide was coming up I have seen it come, and I suspected at the time that it was let out through the sluices at a time when it should not have been let out.

4833. But did you see that, or was it merely some impression that was conveyed to you?—No, I have seen the sluices opened more than once, but not on that occasion.

4834. Have you seen the sewage from the outfalls going into the Thames?—Yes, frequently.

4835. Have you ever seen it on a flood tide?—Yes.

4836. Could you tell me when? Did you take any note of that?—No, I did not.

4837. Had you been watching it with a view of giving evidence, or was it merely that, being interested in the district, you looked at it from time to time?—I have not been watching it with a view of giving evidence. I had no idea that I was likely to be

*Rev. J. McAllister.*

29 Nov. 1882.

called to give evidence on the subject until a few days ago.

4838. Was it for pleasure that you went on the river?—Sometimes I go up and down the river for pleasure, sometimes to visit friends who are living further down or further up.

4839. Did you ever go specially for the purpose of taking observations?—Never.

4840. You merely noticed casually when you were there?—Casually.

4841. Within what periods have you noticed these large deposits of worms that you speak of?—Every summer for the last 9 or 10 years.

4842. Were there any before 9 or 10 years ago on this particular spot?—My attention was not particularly directed to that.

4843. Do you consider the presence of these worms an evidence of the presence of sewage?—A certain kind of worm I should think was.

4844. I do not ask scientifically what is the kind, but what is the appearance of these worms?—Small red worms.

4845. But when you say that they are small, could you tell me how long they are; are they a millimetre in length?—Some of them are two or three inches long, and some are very small.

4846. Were they in large quantities?—Yes, in very large quantities.

4847. A mass of them?—Yes.

4848. And from that you gathered the impression that this was sewage matter in which these worms had either bred or accumulated?—Certainly not. I should not infer from seeing a mass of worms that it was sewage at all. I infer that it was sewage from the smell of it.

4849. Could you tell me when you first saw these worms?—I could not.

4850. Can you tell me when you first examined the sewage which you say was deposited on the side of the river?—I have been examining it, as I told you just now, for the last 8 or 10 years.

4851. Microscopically?—No.

4852. Do you remember that part of the river before the outfalls were established?—No, I do not.

4853. Have you made any investigation otherwise than by taking some of the mud, and looking at it?—No, not by any analysis.

4854. Physically, or chemically, or microscopically?—No.

4855. In what respect does it differ from the mud that is to be found in other parts of the river?—The mud that is to be found in other parts of the river does not emit a smell of an offensive kind, a smell almost always, I think, as far as my knowledge goes, inseparable from sewage in a certain state of decomposition.

4856. Have you ever had an opportunity of examining the mud taken out of a small pond in a gentleman's park, and of observing the smell arising simply from the decaying vegetable matter; have you ever taken it in your hand?—No, I cannot say that I have taken it in my hand; I have smelt it.

4857. Was that very agreeable?—It was not agreeable, certainly, but it was a different smell.

4858. So that you think that you could discriminate at once (I do not put it offensively, but, as you say, you have not examined it scientifically) if two different samples were put before you, so as to be able to say, "This is Thames sewage matter and this is "vegetable matter from a pond"?—I think I could if the mud from the Thames were the mud to which I refer; that is to say, deposit of the heavier part of the sewage.

4859–60. I want you to answer me two questions. I am going to ask you first to tell me precisely the spot where you took the sewage mud; and then to tell me afterwards some spot upon the River Thames where you have taken the ordinary mud of the river with which you have compared it.

(*Chairman.*) I did not understand the witness to say that he had taken samples of the ordinary mud.

(*Witness.*) I did not say so.

(*Mr. Michael.*) He says that it differs from ordinary Thames mud.

(*Chairman.*) You must not assume a fact even in cross-examination. He has not said that he did take any ordinary mud.

(*Mr. Michael.*) I speak with great deference, of course, sir, to your great experience; but if the gentleman says that it differs from ordinary Thames mud, he must have had Thames mud in order to compare it, or else how could he point out the difference?

(*Chairman.*) He does not say that he ever took a sample.

4861. (*Mr. Michael.*) Taking a sample is merely taking a bit. (*To the witness.*) I may have used rather a roundabout expression. Where did you see the mud that you say is contaminated with sewage?—I should like to say that there are certain places in little creeks where there is an eddy of water which carries in the heavier part of the sewage, and it is deposited there. There are other parts, more open parts, where, so far as my knowledge goes, this sewage does not lodge to the same extent, and where you will find the ordinary kind of mud.

4862. All that may be perfectly true, but I wish the Commission to know where is the particular spot where you saw mud deposited which you consider to be sewage mud?—You ask me a question that is very hard to answer. I cannot point out a certain particular spot. I have gone along the banks of the river; there was no particular spot. At such a place as I found mud of that character I would examine it and smell it.

4863. Where are the spots at which you have seen that kind of mud?—There are certain spots lying between the outfall at Crossness and the boundary of the Royal Arsenal at Woolwich.

4864. And those are the spots where you say you have seen sewage mud deposited?—Yes, in some places.

4865. Where is the other part where you have seen mud which you say differs from that on the shore of the Thames?—In the more open parts along the same shore.

4866. That is sufficient for me. Along the more open parts the mud is entirely different. I do not want to ask you any painful question about this scarlet fever in your family, but just a word about this diminution of *vis vitæ*. Yours is a very marshy district, is it not?—No; where I live is a very healthy district, up on the common.

4867. But is it not the fact that your parish is a large tract of alluvial deposit, and very marshy?—No, it is not the fact. Part of it includes the government range, which is a marsh, and part of it is high ground, Plumstead Common for example, which is a rising ground stretching from the marshes.

4868. You said no, and then you at once qualify the no by saying yes, a large portion of your district is marshy?—I should like to be clear on this matter. You ask me a general question whether my parish is not a parish consisting of marshes, and I answer that it is not so. Part of it is marshy land, but more than half of it is high land.

4869. Then half of it is marshy and half is not; shall we put it in that way? At any rate, is a portion of your district of a marshy character?—It is.

4870. When the north-east wind blows over it does it blow over the marshes from the river to the other parts of your parish?—Yes.

4871. You are a gentleman of experience and seem to have thought this matter out, as you talk of *vis vitæ*, what is the general influence of the north-east wind upon the health of a population when that wind blows over marsh land, putting sewage out of the question?—I apprehend that it would depend upon the character of the marshes. If there was a great deal of sour half-decomposed water lying in the marshes, I apprehend that it would be injurious; but

if the marshes were only flat lands and well drained I take it that the effect would not be injurious.

4872. Are your flat lands well drained?—They are supposed to be well drained.

4873. There is nothing of an injurious character in your opinion that could emanate from those marshes?—I do not know.

4874. Do any cases of ague occur in your district?—I have never known a case of ague in the parish since I came to it.

4875. Do you look from week to week at the returns made by the Poor Law medical officer of your district?—I am a member of the board of guardians.

4876. That is not an answer to my question. So you may be, and yet you may never have seen the returns. Do you look at the returns of your Poor Law medical officer?—I do.

4877. And you are able to say that no case of ague has occurred there?—I have never known a single case of real ague.

4878. What is the general health of the district as compared with that of the whole of the metropolis?—Not so good as some, perhaps as good as others.

4879. What is the general mortality per 1000 per annum?—I could not tell that.

4880. But you look every week?—Yes.

(*Chairman.*) Shall we not get that evidence very much better by the returns?

(*Mr. Michael.*) I do not know that they will be here. I have not got them, though I happen to know them. This gentleman is a member of the board of guardians, and he says that he looks at the returns; therefore, I think I am in order in asking him these questions, though I bow with great deference to your decision if you wish to stop me.

(*Chairman.*) I do not say that you are not in order; I only say that the best evidence would be the returns themselves.

4881. (*Mr. Michael to the witness.*) You do not know the rate of mortality in your district?—I know it from time to time by seeing it.

4882. (*Chairman.*) Can you charge your memory with it?—The general impression on my mind is that we stand lower than most of the other districts, and about equal to some of the worst of them.

4883. But you cannot tell us what is the rate of mortality?—I cannot.

4884. (*Mr. Michael.*) Could you tell me supposing that the mortality were 20 per 1,000 in your district, how much of that is attributable to preventible diseases, zymotic diseases?—It is a difficult question for me to answer.

4885. How much is attributable to scarlet fever, do you know that?—Scarlet fever we never get rid of.

4886. And you attribute that to the state of the Thames, do you?—Not altogether. I attribute the violent periodical outbreaks which we have had at certain seasons of the year very much to the poisoning of the atmosphere.

4887. Do the board of guardians take any special means of isolating these cases and preventing the spread of the disease?—We do all we can so to do, but it is a very difficult matter.

4888. Has your medical officer reported to you upon the means to be taken in order to avoid the incidence of these epidemics of scarlet fever?—I do not know that he has made any special report.

4889. Have you had specially brought to your notice the desirability of abolishing cesspools in the district?—That has been done long ago. We have the main drainage in our parish.

4890. But have you discontinued all cesspools?—They are supposed to be discontinued. Wherever the main drainage comes within reach of the houses or streets they are supposed to be drained and connected.

4891. Has the medical officer reported to you specially on wells in connexion with cesspools, and on the pollution of the water from contact with cesspools, or in the vicinity of cesspools?—No.

4892. Neither the medical officer of health, nor the medical officer of the Poor Law?—We have no medical officer of health; they have a local board of health in Woolwich, but not in Plumstead.

4893. But there is a medical officer of health. However, if you do not know it, I will pass that over. Now does typhoid fever prevail in your district?—We have not very many cases, but we have some.

4894. Do you know how many deaths from scarlet fever occurred in your district during last year, 1881?—I could not tell, but there were a great many.

4895. You have given one answer of a very extraordinary character, if you will allow me to say so, when you say that you can detect three or four miles away the sewage smell from the Thames, and that you are able to distinguish that smell from the factory and other smells?—Quite so.

4896. Have you upon the Thames itself during the month that you have given us, that is to say, if I rightly appreciated your answer, in March and April, smelt a smell given off by the sewage in the Thames?—Do you mean last March, or any particular March.

4897. I understood you to say that the two great periods of the year in which the smell of the sewage is distinguishable are March and April, and also September and October; am I right in saying that?—Yes.

4898. Have you in March and April in any year smelt on the Thames itself the smell of sewage which you allege to be prevalent in your district?—Yes.

4899. And do you say that that extends for a distance of three or four miles?—Yes. It depends upon the state of the atmosphere and upon the state of the wind.

4900. Do you know the outfalls of sewage that are still undealt with on the sides of the Thames?—I do not understand your question.

4901. There are two great systems of sewerage in the metropolis, one of which takes the whole of the north of London and the other takes the whole of the south?—Yes.

4902. I daresay you are aware that there are a great number of outfalls still undealt with at Erith and at various other places where sewage discharges itself on the bank of the Thames; do you know that?—I was not aware that there was any place of any magnitude.

(*Chairman.*) Do you mean upon the Plumstead bank?

(*Mr. Michael.*) I am not putting it specifically. This gentleman says that he goes up and down, and I am putting Erith as an instance.

(*Mr. Abernethy.*) You are taking him a long way down the river if you take him down to Erith.

4903. (*Mr. Michael.*) I will ask him about this one, which is in his own district. (*To the witness.*) Do you know the gasworks at Beckton?—I do, very well.

4904. Have you seen the matter that discharges tself from the gasworks at Beckton?—I have.

4905. Have seen the sewage which comes down Barking Creek?—Yes, I have.

4906. Have you smelt it?—Yes.

4907. Does that in any way differ from the smell which you have spoken of; is it fainter or stronger from Barking Creek?—I could not say; it depends so much upon the state of the atmosphere and upon the state of the wind.

4908. Is that the smell which you have noticed in March and April three miles of?

(*Mr. Lumley Smith.*) There is a little confusion I think between Barking Creek and Barking outfall.

4909. (*Mr. Michael.*) I am not mentioning the outfall at Barking, but there is a creek where a very large quantity of sewage discharges itself entirely independent of the Metropolitan Board of Works. (*To the witness.*) You know that, do you not?—Yes.

4910. Have you smelt that that is extremely offensive?—I have never perceived that.

4911. How near have you been to Barking Creek?—Close to it, and on it, and round it, and all about it.

*Rev. J. McAllister.*

29 Nov. 1882.

4912. And you have never been able to distinguish any bad smell either from the banks of Barking Creek or from the water coming down the creek itself?—No, not any particular smell.

4913. You have been close to Barking Creek?—Yes.

4914. And you have seen the spit of land that comes out, and the banks on both sides of the creek and the water coming down?—Yes.

4915. And you have never distinguished anything bad at any time of the year there?—No. I should tell you, in order to be candid with you, that my attention was not particularly directed to making any investigation in that particular place.

4916. But, however, you have not detected any bad smell there?—No, I have not.

4917. Now will you kindly tell me with respect to the other period of the year which you mentioned, namely, in September and October, whether you have detected the same smell of sewage three or four miles in the interior of the country?—I have.

4918. In September and October of this year?—Not so much this year. I have observed that.

4919. And those are the only periods at which this smell is distinguishable?—They are not the only periods, but the worst ones. It depends, as I have already stated, so much upon the wind. When the wind blows in a certain direction, then we get it.

4920. When the wind is from the north-east it blows over the river, and it forces the sewage smell three or four miles into the interior?—Yes.

4921. And that you have noticed every year?—Yes, I have.

4922. Has your attention, as being interested in the public health of the district, ever been directed to the nuisances evolved from the factories on either side of the river?—Yes.

4923. Have you joined with any other boards in striving to mitigate the nuisance arising from those factories?—No.

4924. Have you ever made complaints upon the subject?—Yes, frequently.

4925. Have the board of guardians taken any steps in the matter?—No particular steps.

4926. Have you employed anyone to make a report upon the factories?—No.

4927. Did your medical officer join in making any report, or did he report it to you?—No.

4928. To what public body did you complain when you made a complaint of the factories?—We have not complained to any public body—we have complained bitterly of the nuisances there; but the general impression on the minds of every one to whom I have spoken was this; what is the good of trying to remedy this when the other nuisance of the Thames is so great? You must deal with it as a whole.

4929. Have the guardians passed any resolution with respect to these nuisances?—No.

4930. Or with respect to any nuisances at all?—No.

4931. Have they ever taken any active steps as a board of guardians?—No.

Examined by the COMMISSION.

4932. (*Dr. de Chaumont.*) With regard to the depression of *vis vitæ* that you speak of, have you observed any difference in that during the long time that you have been in Plumstead?—Yes, I have noticed it, as far as one could measure it, it is not the kind of thing that you could measure exactly; but I certainly have noticed that at certain seasons of the year when patients, in whom I am particularly interested, complain of this kind of thing and when I take them to a medical man, his pharmacopœia consists almost entirely of quinine.

4933. Is that more the case than it used to be?—Yes.

4934. Have you yourself felt the effects of this depression?—Yes.

4935. And you think you feel it more now than you did?—I do. Perhaps that is not a safe guide because I am not quite so young as I used to be.

4936. But you think it has been increasing?—I do.

4937. You have no local board of health, have you?—There is a local board of health at Woolwich, but not at Plumstead.

4938. Then the board of guardians is the sanitary authority?—Yes.

4939. But you have a medical officer of health?—Perhaps I am misleading you. The board of guardians is not altogether the sanitary authority, but there is the Plumstead Board of Works which takes cognizance of sanitary matters.

4940. Then are you directly under that board of works for sanitary purposes? When nuisances take place do the complaints go to the board of works?—There are certain sanitary things which come under the cognizance of the district board of works, and certain others which come under the cognizance of the board of guardians; but of course, anything connected with the sewage would be referred to the board of works.

4941. But you have a medical officer of the district?—Yes.

(*Mr. Michael.*) There must be a district board of works at Plumstead, and the district board of works is the sanitary authority for the district, and they are obliged to have a medical officer of health.

4942. (*Chairman to the witness.*) How far is your house from the railway, in a straight line?—About half a mile.

4942*a*. The Plumstead marshes begin just about the railway, do they not?—Yes, that is to say, they extend from the railway towards the river, and then the higher ground slopes up towards Plumstead Common.

4943. Then your house is within half a mile of what are called the Plumstead Marshes?—Yes.

4944. (*Dr. Stevenson.*) Do you know Silvertown and that district?—Yes.

4945. That will be within three miles of your house, I suppose?—As the crow flies, I should think it would.

4946. Are there any chemical factories there that you know have been complained of?—I have not heard of any complaints.

4947. You know that there are chemical factories there, where they distil tar and make chloride of lime?—Yes.

4948. You have not heard them complained of?—No.

4949. Have the inhabitants of your district, or of any of the districts in the neighbourhood, complained of these works generally, about Silvertown?—No.

(*Mr. Michael.*) It is two-and-a-half miles; we have measured it.

4950. (*Chairman to the witness.*) You mentioned that you had smelt that peculiarly offensive smell three or four miles away from the river—do you recollect at what place you were when you smelt it?—Yes, at East Wickham; I have frequently smelt it when I have been at the residence of Mr. Jones, who lives at East Wickham House.

4951. Is that the most distant point at which you have smelt it?—Yes. That is more than three miles from the outfall.

4952. (*Sir John Coode.*) You told us that there were some occasions on which you yourself had seen the outfall sluices actually opened?—Yes.

4953. About how many times have you seen that yourself?—Perhaps a dozen times.

4954. Did you take a note of the state of the tide on those occasions, whether the tide was ebbing or flowing, or how?—Yes; I have noticed more than once that the tide appeared to me to be coming up instead of going down.

4955. You did not know the time of high water, because the tide may flow along the shore before high

water?—Of course, I do not like to speak very positively upon that matter: but I merely tell you the impression that was made upon my mind at the time when I saw the sewage floating up.

4956. My question refers to the time at which you yourself saw the outfall sluices opened, and you say that on several occasions you saw them opened at a time when the current was running up stream?—Yes.

4957. (*Colonel Ewart.*) You have told us the nature of your means of disposing of the sewage; but I do not think you have told us what is the nature of the water supply generally in your parish; is it from wells or from waterworks?—Artesian wells. The North Kent Waterworks supply the water and it is said to be the best water in the neighbourhood of London.

4958. (*Chairman.*) Is your house supplied by the waterworks?—Yes.

4959. And was it so at the time when you had these unfortunate attacks of scarlet fever?—It was.

4960. (*Sir John Coode.*) And is the surrounding district generally supplied by the same waterworks?—I believe the whole district is supplied from the Kent Waterworks.

4961. (*Colonel Ewart.*) As regards these marshes that you speak of, can you say from your general observation whether there is much stagnant matter there, or are they relieved by a system of drainage?—They are relieved by a system of drainage; there is a perfect system of drainage. The Government, I think, look to their own part of it, that part of the marshes which is covered by the Government range; and then there are arrangements made for draining the other part and draining it perfectly by means of sluices which are opened at certain times.

The witness withdrew.

Mr. Henry Passfield called in; examined by Mr. Balfour Browne.



4962. Where do you live?—At Lambeth.

4963. What are you by trade?—A fisherman.

4964. What is your age?—Forty-five.

4965. How long have you fished in the river?—Over 30 years.

4966. What parts of the river do you principally fish in?—Up the country in the first part of the year, up to about August.

4967. Do you fish down the river at all?—Yes.

4968. What do you mean by "up the river," above this place where we are now?—Yes, up from about Chiswick, in all parts.

4969. (*Chairman.*) Do you go from this to Chiswick or do you go above Chiswick?—I have been to Sunbury.

4970. How far up the country are you in the habit of fishing?—Say from Sunbury down.

4971. (*Mr. Bidder.*) Down to where?—I have been down to Hungerford.

4972. (*Chairman.*) You are in the habit of fishing between Hungerford and Sunbury?—Yes.

4973. (*Mr. Balfour Browne.*) Do you ever fish below Hungerford, further down the river more towards the sea?—Yes.

4974. How low down do you fish?—Down as far as the Lower Hope Point I have been.

4975. Does it depend upon the time of the year whether you are fishing up the river or down the river?—Yes.

4976. Can you notice any change in the river in recent years?—Yes.

(*Mr. Bidder.*) Is not this the very thing that was admitted?

(*Mr. Balfour Browne.*) It is not the same thing.

4977. (*Chairman to the witness.*) What change have you noticed in the river in recent years?—About five or six years after the sewage came into the river from the outfalls at Barking and Halfway Point, it took an effect upon the river.

4978. How did it affect the river then?—We could not catch the fish there.

4979. (*Mr. Balfour Browne.*) What fish were you in the habit of fishing for?—Shrimps.

4980. Did you ever fish for flounders?—No; I never followed flounder catching.

4981. Was it only the shrimp that you went about?—What I fished after for my living was eels.

4982. Do you know Limehouse Reach?—Yes.

4983. Are there any fish to be caught in Limehouse Reach now?—No; I have known them to catch a few for one day or so, but I have never caught any there myself.

4984. Limehouse Reach is above the outfalls, is it not?—Yes, a few miles above.

4985. Are the fish, according to your view, driven away from Limehouse Reach in consequence of the sewage?—No; I have never worked from there.

(*Mr. Bidder.*) I must object to that as a leading question.

(*Chairman.*) The value of the evidence is of the very slightest description.

4986. (*Mr. Balfour Browne to the witness.*) Can you tell the Commission whether flounders, dace, roach, and eels can be caught in the river at Hungerford Bridge?—Yes, at certain times of the year.

4987. At what time of the year can they be caught at Hungerford Bridge?—About August and September.

4988. Can they be caught any lower down the river?—No; not without you go right down below Gravesend.

4989. Can you tell the Commission at what point they can again be caught going down the river?—Yes, down below Gravesend.

4990. So that, although at certain seasons of the year, you can catch these fish at Hungerford Bridge, you cannot catch them between Hungerford Bridge and below Gravesend?—That is so.

Cross-examined by Mr. Bidder.

4991. Do you catch roach and dace down at Gravesend?—No.

4992. But you do catch roach and dace down by Hungerford Bridge?—Yes.

4993. My learned friend asked you if you also caught them below, and you said that you caught them down below Gravesend?—No; roach and dace are fresh-water fish, and the lowest that they reach is down to here according to the tides.

4994. They never go into the salt water?—No.

4995. Therefore, it is a mistake to say that they are caught below Gravesend; eels of course may be caught below Gravesend?—Yes; eels are salt-water fish as well as fresh-water fish.

4996. And shrimps and flounders?—Yes, and whitebait.

4997. Eels you catch both up the river and down the river, do you?—Yes.

4998. I daresay you can tell me something about the eels; they go down to the sea at certain times of the year, do they not?—No, these eels that you catch up this way are of a different class.

Examined by the Commission.

4999. (*Chairman.*) You said that you fished down from Hungerford to Gravesend; is that so?—No.

5000. (*Mr. Balfour Browne.*) Will you explain how that is?—When you are going down for salt water fishing, you have to put different gear in the boat; and if you are fishing up the river this week, say, you put the other gear in the boat, and then if you want to shift down to below Gravesend you put the salt water gear in the boat.

5001. (*Sir John Coode.*) Do you ever try to catch fish between Hungerford and Gravesend?—No.

*Mr. H. Passfield.*

29 Nov. 1882.

5002. Why not?—Because we cannot do so now on account of the sewage. We used to work for eels in Halfway Reach, Barking, Greenhithe, Erith, and Long Reach, and we never used to think of going further.

5003. Are there or are there not fish between Hungerford and Gravesend?—No; nothing will live there in warm weather.

5004. That is the reason?—Yes.

5005. You are sure of that?—Yes.

5006. You have tried it?—Yes.

5007. For how long has that been the case?—Five or six years after the sewerage had been started we could not catch any eels at Erith; and then every year it got worse by degrees. Then we had to work at Greenhithe.

5008. Then you mean to tell us that the fish have disappeared now between Hungerford Bridge and Gravesend?—Yes.

The witness withdrew.

(*Mr. Bidder.*) As I said many meetings ago, I say again now, that there is no doubt that the fish have so far disappeared in that middle reach of the river that it is not worth a man's while to fish there now.

(*Chairman.*) Then we need not have any cross-examination upon that point.

Mr. WILLIAM HENRY LEWIS called in; examined by Mr. LUMLEY SMITH.

*Mr. W. H. Lewis.*

5009. I believe you reside at King William Street, Greenwich?—Yes.

5010. And I believe you are the Port Sanitary Inspector?—Yes, under the Corporation, the Port of London sanitary authority.

5011. What is the extent of your district?—The extent of the jurisdiction of the sanitary authority is from Teddington Lock down to the north-east corner of the Isle of Grain.

5011*a*. (*Sir John Coode.*) Have you charge of the whole of that district?—That is the jurisdiction of the sanitary authority.

5011*b*. (*Mr. Lumley Smith.*) Are there more inspectors than yourself?—Yes, there are two others.

5012. Have you any particular part of the river to attend to, or do you go over the whole?—I am chiefly engaged between Greenhithe or Erith, and, say, up as far as Battersea. That is my usual work. There are times, of course, when I am down at the two ends; that is to say, at the higher and the lower end.

5013. But you are specially conversant with the part of the river that you have told us of?—Yes.

5014. How many years have you been in that capacity?—Since 1873; the date of the formation of the authority.

5015. Does your duty take you constantly on to the river?—Yes, in some portion of it.

5016. Every day, or how often?—Every day.

5017. Have you noticed in the course of the time which has elapsed between 1873 and the present time, any change in the character of the river?—A most decided change.

5018. Will you tell the Commission shortly what the change has been?—Take, for instance, the year 1880. The river then was very black indeed during the summer, say from Jenningtree Point right up pretty well to the Cherry Garden Pier. That was in July 1880.

5019. That was a very bad time?—Very bad indeed.

5020. Bad in what respect?—It was in black patches; it seemed like floating mud, as it were, in black stinking matter. As soon as you touched it it tumbled to pieces. This black floating stuff on the water seemed as if it came from the bottom, as though it had been drawn up by the heat.

5021. It seemed to have come up in patches from the bottom, and then it floated on the top?—That is so.

5022. Did it break up then, or did it break when it was touched?—It broke up at the slightest touch.

5023. But the patches might be the size of a table, or they might be the size of a room; what was their size?—They were all kinds of shapes; the large ones would be about six to eight feet in length, and the small ones would be about half that; and their breadth would vary from three feet to six feet, speaking roughly.

5024. Did that have the appearance at all of common Thames mud?—Oh, no, not at all.

5025. Was there anything else about it; was it offensive in any way?—Very offensive.

5026. In what way?—There was a fearful stench with it.

5027. This you say was in July 1880; did that last for any considerable time in 1880?—It lasted nearly the whole of the month of July, up to the early part of August, and then it came on to rain, and there was a thunderstorm, and down went this thick stuff, and it did not appear again during the wet season after the rain came.

5028. (*Chairman.*) Never again?—Not then.

5029. (*Mr. Lumley Smith.*) Had that occurred before within your knowledge?—In 1858.

5030. You have known the river for a long time, I presume?—At that time I was connected with the Dreadnought Seamen's Hospital.

5031. Where was that moored?—It was moored off Greenwich.

5032. In 1858 do you remember anything similar to what you saw in 1880?—There was a greater amount, and it lasted for a longer time.

5033. (*Mr. Bidder.*) Was it worse?—Yes, because these patches extended the whole width of the river; in fact then it was a black ditch.

5034. The same sort of thing as occurred in 1880, but much worse?—Much worse.

5035. (*Sir John Coode.*) Was it in the same part of the river?—No. In 1858 it was in the part from Greenwich up to London.

5036. (*Mr. Lumley Smith.*) It was a bad time then in London?—Yes.

5037. That was of course before the Metropolitan drainage was in force?—Yes.

5038. At that time you saw something similar between Greenwich and London?—Yes.

(*Mr. Bidder.*) Much worse.

5039. (*Mr. Lumley Smith.*) Was it in patches?—No; it was one full black ditch.

5040. (*Mr. Abernethy.*) In what part of the river did you see the patches that you spoke of first, and which you saw in July 1880?—Say from Jenningtree Point up to near Cherry Garden Pier.

5041. (*Mr. Lumley Smith.*) In July 1880 these patches did not pervade the Thames for the whole of the year; but in other parts of the year have you noticed anything in the river at all; has there been any change in the character of the river?—Yes; after, say 1864, the river seemed very good; and during these last six or eight years, speaking roughly, the river has assumed rather a bad character; it has been getting gradually worse than it was prior to that time.

5042. (*Chairman.*) What do you mean by getting worse?—Take the northern outfall or the southern outfall: the river there assumes a very black appearance and smells very badly.

5043. Then what you mean by its getting worse, is that it is getting blacker and smells worse?—Yes.

5044. (*Sir John Coode.*) Within the last six or eight years?—Yes.

5045. (*Mr. Lumley Smith.*) Has there been any recurrence of this appearance of the patches since July 1880?—At times there has been a little. I think that in July this year it began to be rather bad.

5046. (*Mr. Bidder.*) But not so bad as it was in 1880?—No.

5047. (*Mr. Lumley Smith.*) Have you noticed sewage in the river?—Oh, yes.

5048. Have you ever noticed it coming up stream?—Yes; that is a thing that you can see very frequently at Barking.

5049. I will come to some observations that you took a little later; but you have seen it coming up stream at Barking; how far up the river have you seen it from Barking?—There have been times when I have traced it,—I could not say whether it came from Barking or from Crossness,—but I have traced it up to the lower part of Blackwall Reach.

5050. (*Sir John Coode.*) When was that?—At different times.

5051. More than once?—Yes, frequently.

5052. (*Mr. Lumley Smith.*) When you say that you traced it, were you able to trace it as having come from Barking or from Crossness, or may it have come from some outfall on the other side, or elsewhere?—You could see it from either one place or the other, either Barking or Crossness.

5053. There is a distinct track?—Yes, quite so. You might lose the track for about half a dozen feet or half a dozen yards; but you can see a distinct track from Barking or Crossness.

5054. You are not speaking of Barking Creek?—No, of the Barking outfall.

5055. You say that you may lose it for a few feet, but that you come upon it again?—Yes.

5056. You are able to distinguish that this sewage, which you trace up the river Thames, comes from the outfalls?—Yes.

5057. Of course if it is flowing up stream, the tide must be flowing?—Yes.

5058. Did you take any samples of the water in 1880, at that bad time that you are speaking of?—I took some samples once; I was with the medical officer.

5059. Who was that?—Dr. Collingridge.

5060. (*Mr. Bidder.*) Where?—At Jenningtree Point, at Purfleet, by the "Cornwall," and at Charlton inside the "Warspite."

5061. Were the samples taken at high water or at low water?—They were taken on the flood.

5062. (*Sir John Coode.*) At different periods of the flood tide?—In commencing from Jenningtree Point it would allow, you may say, before we got to Charlton, an hour and a half.

5063. (*Mr. Lumley Smith.*) Did you examine it yourself to see what was the nature of the water?—Only by smelling it.

5064. What was the smell like?—A stink.

5065. Did it smell like pure water, or what did it smell like?—Like sewage.

5066. On the 30th of June 1882, that is to say this year, I am told that you were again with Dr. Collingridge?—Yes.

5067. Did you take some samples then?—Yes, there were several samples taken then.

5068. You recollect the occasion?—I do; there were several gentlemen present at the time.

5069. Can you tell us where the samples were taken?—Yes; No. 1 was taken within Barking Creek, a little way up from the mouth, on the ebb.

5070. (*Chairman.*) Was it low water?—No; the tide had fallen, roughly speaking, say twenty minutes.

5071. (*Mr. Bidder.*) About half an hour after high water?—Yes. Then I cannot tell you exactly where No. 2 was taken; but there were several samples taken as far down as Gray's.

(*Sir John Coode.*) It is very material to know where the samples were taken.

(*Mr. Bidder.*) A great deal turns upon this.

(*Mr. Lumley Smith.*) Dr. Collingridge was with him.

5072. (*Chairman to the witness.*) Did you take any note of the places where you took those samples?—Yes, I have them in my daily book.

5073. Then look at your book and refresh your memory. Those are entries made at about the time?—Yes.

5074. Were they made by yourself?—They were made by myself.

5075. Look at those entries and tell us where the first sample was taken?—At Barking Creek, a few yards up the creek, at 2.25. No. 2 was taken close in at Lawes' Chemical Works at Barking at 2.30. No. 3 was taken at Barking in a line with the sewage, about 200 yards below the Barking outfall, the time at which it was taken being 2.35.

5076. (*Sir John Coode.*) What time was it high water that day?—It was high water at London Bridge at 1.9 p.m. No. 4 was taken at Halfway House Point on the south shore off the surface, about 30 feet from the bank, at 2.50. The others were taken at a depth of two or three feet. No. 5 was taken at about 50 yards above the outfall at Crossness.

5077. (*Mr. Lumley Smith.*) Was that off the surface or below?—Below. The time at which it was taken was 2.55.

5078. About how deep did you go to get the samples on those occasions?—About three feet.

5079. I think you have got a sixth sample, have you not?—Yes; that was taken at Crossness over the line of sewage discharging from the outfall; that is in the direct line of the sewage as you trace it down. The time when that sample was taken was 2.59.

5080. Is that taken from the surface?—No.

5081. Unless you tell us it is from the surface, we may assume that it is not?—Yes.

5082. Now, then, going to No. 7, where was that taken?—Off the second jetty at Crossness pumping station, in a line with the shaft, about 120 feet off the quay, at 2.59

5083. (*Mr. Michael.*) There are three jetties at Crossness?—Yes.

5084. (*Mr. Lumley Smith.*) Now, will you give us No. 8?—No. 8 was taken at the West Kent tanks from the upper and middle reservoirs, about half of each, the time being 3.55.

5085. They are all taken, I see, on the same afternoon and within a short time after each other?—Yes.

5086. I think Dr. Collingridge, the medical officer of health, was in the boat with you?—Yes.

5087. Have you any others?—Yes, I have three others. Then sample No. 9 was taken at Greenhithe in a line with the causeway, the time being 5. 40.

5088. What part of the channel was it in?—Close in shore.

5089. What are your other two samples?—No. 10 was taken at Barking, at the sewer at low water, the time being 7.10, and the outfall running with great force.

5090. (*Mr. Bidder.*) In a line with the discharge of the sewage?—This is into the mud.

5091. (*Mr. Lumley Smith.*) Where was No. 11 taken?—No. 11 was taken at Barking at 150 feet below the outfall; that is taken from the bottom.

5092. (*Mr. Bidder.*) How far out from the shore?—Close in shore; the bottle stuck to the bottom. The time at which that sample was taken was 7.15.

5093. (*Mr. Lumley Smith.*) Was the outfall still running then?—Yes.

5094. Dr. Collingridge was in the boat with you, was he not?—Yes, he was.

5095. And I think Dr. Tidy?—Yes.

5096. And Mr. Baldwin Latham, I think?—Yes, and other gentlemen. I do not know their names.

5097. I believe that you also took some observations from midday on the 28th of July to 10 o'clock a.m. on the 29th of July in the present year?—Yes.

5098. And I believe that you carefully watched the times at which the sewers were running?—Yes.

5099. Where were you stationed?—At the Crossness pumping station.

5100. How far from the outfall?—Right at the outfall.

5101. I do not know whether you found it a pleasant night's work?—The stench was awful. I had one night of it. The beauty of it was that Saturday was the next day, and on Sunday we could square ourselves again.

*Mr. W. H. Lewis.*

29 Nov. 1882.

5102. (*Sir John Coode.*) Were you afloat or on shore at this time?—I was in a boat all the night.

5103. (*Mr. Lumley Smith.*) It would be about 60 or 70 feet off the quay, I suppose?—It would be somewhere near that. I was in an open boat sampling the water the whole of the night—in fact, the whole of the day too—for 24 hours; and I sampled this water direct at the outfall. The outfall is situated at the upper portion of that part of the Crossness pumping station, just about one fourth of the quay, just above the jetty, and in a line with the jetty; and I was quite certain of getting at the outfall, for my bottle, which I sampled the water in, caught in this outfall.

5104. In the stream you mean?—Yes.

5105. I believe you have the entries in your book, have you not?—I have.

*The following paper was handed in.*

CROSSNESS PUMPING STATION.

SAMPLE WATER taken from the OUTFALL from MIDDAY 28th July to 10 o'clock July 29th.

28th July, morning. High water, 11.53.
29th July, morning. High water, 12.23.

Wind—Light, changeable.

| No. | Time Sample taken. | Place. | Remarks. |
|---|---|---|---|
| 1 | July 28th, mid-day, 12.0. | Near the upper outfall. | About 60 to 70 feet off the quay near the centre, about three feet below surface. |
| 2 | 1 p.m. | Do. | Near the same place at 1.40. Stinks badly. (Sewer running.) |
| 3 | 2 p.m. | Do. | 18 feet below surface. (Sewer running.) |
| 4 | 3 p.m. | Do. | Do. 17 feet below surface. (Sewer running.) |
| 5 | 4 p.m. | Near this same place, 16 feet below surface. | 3.5 observed the lower outfall running. Water discoloured and warm. 3.0 felt the outfall; supposed wood. |
| 6 | 5 p.m. | Do. 11 feet below, four or five feet from edge of water (or mud). | About 4.0 upper outfall stopped running. (Lower sewer running.) |
| 7 | 6 p.m. | Do. do. | Three to four from water edge. Water warm; smell very bad. (Lower jetty outfall still running.) |
| 8 | 7 p.m. | Do. 16 feet from the mud. | 15 feet below surface. |
| 9 | 8 p.m. | Do. about 70 to 80 feet off quay. | 16 do. do. |
| 10 | 9 p.m. | Do. do. | 16 do. do. foggy. |
| 11 | 10 p.m. | Do. do. | 18 do. do. (10.15 foggy). |
| 12 | 11 p.m. | Do. do. | 18 do. do. (11.20 the upper outfall opened). Stopped, should think, about 3.30; it then seemed to run till 4 o'clock. |
| 13 | 12 midnight | Three or four feet from surface. | All taken near same place. (Sewer running.) |
| 14 | July 29th, 1 a.m. | Do. do. | Do. do. do. |
| 15 | 2 a.m. | From the bottom | The bottle caught in outfall 2.15 before it was cleared, 18 feet below surface. (Sewer running.) |
| 16 | 3 a.m. | Do. do. | 17 feet below surface. (Sewer running.) Stinks. |
| 17 | 4 a.m. | Do. do. | Do. (very foggy). |
| 18 | 5 a.m. | Do. do. | 11 feet below surface. |
| 19 | 6 a.m. | Do. do. | Do. (very foggy). |
| 20 | 7 a.m. | Near the upper outfall. | 10 feet do. (Lower outfall still running). |
| 21 | 8 a.m. | Do. do. | 11 feet below surface. |
| 22 | 9 a.m. | Do. do. | 16 do. do. |
| 23 | 10 a.m. | Do. do. | 18 do. do. |
| 24 | 8.15 (A.) | Off the surface | Flood tide. Notice sewage coming up with the flood (with soil). Traced it up to Crossness Point, and then over to the other side to Bridge's Powder Magazine. It was seen also in the Blackwall Reach. |

At low water there is a hill near this upper outfall which *stunk fearfully*.
The upper outfall is below the low-water mark: can feel it. It seems to be wood, about five or six feet in breadth, and about the same in height.
During the night near the outfall stunk very much.
All these samples were taken in about the same place.

5106. (*Mr. Lumley Smith.*) When was No. 1 taken?—At midday.

5107. What is your remark about that?—This is near to the upper outfall, about 60 to 70 feet from the quay, and three feet below the surface.

5108. Have you any note about the sewer?—No.

5109. (*Sir John Coode.*) Was the sewer discharging at this time?—That I have made no remark upon, but I have no doubt it was.

(*Mr. Michael.*) It was high water at London Bridge at 11.52 that day.

5110. (*Mr. Lumley Smith, to the witness.*) What is your note as to No. 1?—"Near the upper outfall, "about 60 to 70 feet off the quay, near the centre, "about three feet below the surface."

5111. (*Sir John Coode.*) And you do not know whether the sewer was running at that time or not?—It would be running.

5112. (*Mr. Bidder.*) It was probably running; it was 40 minutes after high water?—That would be my object in taking it from the surface.

5113. (*Mr. Lumley Smith.*) What are the particulars with regard to No. 2?—No. 2 was taken at 1 p.m. near the same place. I have no remark but simply this, "Stinks badly, sewer running."

5114. The next was taken at 2 p.m.?—Yes, it was taken near the upper outfall, from the bottom, 18 feet below the surface.

5115. When was the fourth sample taken?—It was taken at 3 p.m., near the same place, and 17 feet below the surface. At 3 o'clock I felt the outfall, which seemed to be made of wood. You cannot see the outfall, and I had to do it with a line, and I worked my line along, the same as you might work it along the edge of a table, and you could feel then by the chafing of the line that you had come in contact with the wooden sewer.

5116. When was the next sample taken?—At 4 p.m. near the same place, and 16 feet below the surface.

5117. Have you any entry there about the outfall running?—At 3.5 I observed the outfall at the lower jetty running, water discoloured and warm. At 4 p.m. the upper outfall stopped running. At 11.20 p.m. the upper outfall commenced running, and stopped running at 3.30.

5118. (*Chairman.*) You noticed that?—Yes, there is no difficulty whatever in seeing when that outfall is opened. Then it commenced again directly after that, and ran on until 4 o'clock a.m. of the 29th.

5119. (*Mr. Lumley Smith.*) What is your note at 6 p.m.?—There is a fearful mud bank by that outfall. My note is, "There is a mud bank near this upper "outfall which stinks very much." I cannot describe it; it is fearful. The boatman happened to put his oar in there. I had a man and a boy in the boat, and it knocked the boy up; he was ill for a day or two after that. It was really shocking. It is not an easy matter to describe stinks.

5119*a*. Have you any note at 2 a.m.?—At 2 a.m. my bottle caught in the outfall, and I was 15 minutes before I got it clear.

5120. About 4 a.m. it began to be foggy, I believe?—Yes; in fact, it began to be foggy at 9 p.m., and lasted till the next morning, and the next morning it was a beautiful day.

5121. Have you a note as to 8.15?—I noticed the sewage returning on the flood, and traced it from the powder works up to the point at Crossness, and then over to the north shore to Bridge's powder magazine. Saw soil on the south side.

5122. (*Mr. Bidder.*) Where is Bridge's powder magazine?—It is just below these chemical manure works. There are Lawes's manure works and there are Crowe's works, and then comes the powder magazine.

5123. (*Mr. Michael.*) It is below the Barking Guano Works, is it not?—Yes.

5124. (*Mr. Lumley Smith.*) I believe you labelled all these bottles, did you not?—Yes.

5125. And what did you do with them?—I took them to Dr. Tidy.

2126. I believe that during this month you have been taking some other samples?—I have.

2127. On the 16th of this month you were with the medical officer, were you not?—Yes.

5128. Where did you take your samples then?—We were down sampling mud, and I noticed, on going down, that the water was just on the turn.

5129. Did you notice sewage then?—Yes.

5130. How was the tide?—The tide then was just upon the make. It had turned, and was coming up again.

5131. Did you notice where the sewage was going?—Three of the outfalls at Barking were running with great force, and we came right into the line of it in coming from Beckton. All that sewage was passing up the river, and we were going down the river.

5132. That was at a time when the tide was beginning to make?—The tide was making.

5133. And those outfalls were running fast?—With great force, the three upper ones.

5134. How many outfalls are there altogether?—Nine, I think.

5135. When you had the samples labelled what did you do with them?—They were taken to Dr. Beale.

5136. Whereabouts in the river did you take those samples?—I took three samples of mud. I took No. 1 opposite the clock next the pumping station at Crossness; No. 2 near the upper outfall in a line with the jetty; and No. 3 opposite the house between the Government powder magazine and the powder jetty, about 100 feet from that place. There were only three samples taken that day.

5137. Those you labelled and kept separate, I suppose?—Yes.

Cross-examined by Mr. BIDDER.

5138. You say that these three samples are taken from the mud upon the shore; are they taken from mud fresh up from the bottom?—From mud taken up from the bottom of the river.

5139. How far from the shore?—60 feet or thereabouts.

5140. Is the place that you describe as being between the Government powder magazine and the powder jetty, also at Crossness?—Yes, it is just above, this side of Crossness.

5141. About how many feet or yards would it be above the outfall?—It would be 600 or 700 yards, roughly speaking, above the outfall.

5142. That would be round Halfway House Point or Leather Bottle Point.

5142*a*. (*Chairman.*) Was it round the point that you took these samples?—No, I think it was the other side of the point.

5143. (*Sir John Coode.*) A little below the point?—Yes.

5144. (*Chairman.*) On the same side as the outfall?—Yes.

5145. (*Mr. Bidder.*) My Admiralty chart seems to show that the magazine is round the point, above the point?—It would be round the point.

5146. (*Chairman.*) Do you recollect whether it was above or below the point?—(*After referring to the chart*). It is about here (*pointing it out*).

5147. Then it was above Crossness?—Yes.

5148. (*Sir John Coode.*) Then it must be more than 600 yards?—The gentleman asked me roughly, and I spoke roughly. Just for the moment I could not remember where it was.

5149. (*Mr. Bidder.*) As regards the other samples, I think you have sufficiently definitely indicated them. With reference to the condition of the river itself, is it not the case that there are a considerable number of foul outfalls within your district, discharging into the river, quite distinct from the outfalls of the Metropolitan Board of Works?—Yes.

5150. And some of them discharge considerable quantities of sewage?—Do you mean within the jurisdiction of the Port of London Sanitary Authority?

5151. Yes?—Yes.

5152. Is there not a considerable amount of sewage coming from one that has been mentioned, viz., Barking Creek?—Then are one or two small affairs there within the creek.

5153. I do not know how far your jurisdiction goes up the creek; but you are aware that a considerable amount of sewage comes down the creek?—There are some smaller ones, and one larger one, for the relief of the town; but at any time when you are passing up the creek you would not observe any soil floating about that place. There are a few small ones, such as a closet or a privy, and a larger one at the head of the creek.

5154. Does your jurisdiction extend right away up Barking Creek to the river Lee?—No.

5155. Whatever there is above you, you do not take any notice or cognisance of beyond your own jurisdiction?—No.

5156. Do you know one at Beckton?—Yes.

5157. Is there a discharge from that which at times is offensive?—Sometimes it may be.

5158. (*Chairman.*) You have noticed it?—Yes.

5159. (*Mr. Bidder.*) What is the size of that Beckton outfall, by-the-bye?—It is of an egg shape, speaking roughly, about 18 inches in breadth by 23 inches or 2 feet. It is not exactly egg shape, but it is not round.

5160. Do you know higher up where the Blackwall outfall comes into the river?—Yes, at Bow Creek, you mean?

5161. Yes. Is it not the case that you have some very large outfalls there, the sewage of West Ham for instance?—That is the largest of all up there; the others are privies.

5162. What is the size of the West Ham outfall, speaking roughly?—That is a small affair, and you can only see it at dead low water.

5163. You do not know its size?—No.

5164. You know that it drains a large district, perhaps?—I know nothing about the district.

5165. Is it part of your duty to make returns, and to report upon any foul outfalls?—Yes, at stated times, when ordered by the medical officer.

5166. Have you got in your book any memoranda or account, or list of the foul outfalls within your district?—No, I have not any with me; but I can tell you roughly, I think.

5167. Will you tell me roughly how many there are?—Taking the Poplar district, I should reckon that there are at least 40 privies or closets in Poplar.

5168. Then at Limehouse, how is it?—At Limehouse they are getting rather slack; they are clearing away some of theirs. I suppose there would be eight or ten at Limehouse.

5169. Perhaps it would be better not to guess. Have you not in point of fact made reports which are embodied in the reports of the Port of London Sanitary Authority, which will give the exact number?—Yes, I have made reports.

5170. I have here a Blue Book which purports to be a report of the Port of London Sanitary Authority for December last; is that list of foul outfalls on the two sides of the river prepared from your materials?

5171. (*Chairman.*) Was that return made by you?—Yes.

5172. (*Mr. Bidder.*) Is that an accurate return?—At that time it was.

5173. (*Mr. Abernethy.*) What is the date of that report?—December 15th 1881.

5174. (*Mr. Bidder.*) I see that there were 187 on the north side of the river, and 182 on the south

*Mr. W. G. Lewis.*

29 Nov. 1882.

side; and that was accurate at that time. Is it your duty to visit vessels in the river for sanitary purposes?—Yes.

5175. Do you find the health of the seafaring population on the river to be generally good?—Yes.

5176. There is no alarming amount of epidemic disease amongst them?—No; none at present, thank God.

5177. I believe you are rather proud in the Thames of the healthiness of the port, as compared with other ports?—Oh, yes.

Re-examined by Mr. Lumley Smith.

5178. One word about the list of foul outfalls which has been put into your hand. I understood you to say when you spoke of Poplar that there were about 40 there; I see that the number appears in this list as 41?—Well, that is a pretty good guess.

5179. Under the head of foul outfalls are you including closets or privies?—Yes.

5180. This number of outfalls does not mean sewers only?—Decidedly not.

(*Mr. Bidder.*) Some are big and some are little.

5181. (*Mr. Lumley Smith.*) But it does include privies and closets?—Yes.

5182. Have you any materials for showing how many of these, which are all classed as foul outfalls, are sewers, and how many are merely the privies or closets of single houses?—I have no documents with me at present; but if you would allow me I would call your attention to Rotherhithe.

5183. Rotherhithe appears in this list, I think, as having 19?—I venture to say that all but one of those would be closets simply for the waterside houses.

5184. (*Sir John Coode.*) When you say closets you mean for a single house?—Yes; or there might be a second house or a third house that made use of it. That, of course, I cannot say.

5185. Then would you say at most three houses?—That would be pretty well a sewer for three houses.

(*Mr. Bidder.*) I take it that he can scarcely say more than that they are small drains.

(*Mr. Lumley Smith.*) I notice that out of the 187 foul outfalls on the north side, 117 are stated to be within the jurisdiction of the Board of Works, and of the 182 on the south side 59 are said to be within the jurisdiction of the Board.

5186. (*Chairman to the witness.*) In point of fact, whatever return you made, what you mean by foul outfalls is large and small outfalls?—Yes.

5187. (*Mr. Lumley Smith.*) I see that your jurisdiction extends up to Teddington on both sides?—Yes.

5188. You were asked about Bow Creek; have you examined the sewer at all in Bow Creek?—Yes.

5189. There is an outfall of the Metropolitan Board of Works there, is there not?—There is.

5190. Have you ever seen that at work?—Yes.

5191. Was there much sewage coming out?—Yes; foul stuff.

5192. How often have you seen that?—Not so very often.

5193. That is what I believe is called the storm outfall?—Yes.

5194. With regard to Barking, my learned friend asked you whether you took any cognizance of Barking Creek and you answered his question in the negative; have you examined the sewers in Barking Creek?—

(*Mr. Bidder.*) I said he did not take cognizance beyond his jurisdiction.

5195. (*Mr. Lumley Smith to the witness.*) Have you observed the sewers in Barking Creek?—Yes.

5196. Are they large or small?—There is only one sewer to my knowledge.

5197. Does that pour down any substantial amount of sewage?—It is very seldom that I have seen that.

5198. (*Sir John Coode.*) Does Barking itself drain into the main sewerage system?—That I cannot answer.

(*Mr. Bidder.*) It does not.

(*Chairman.*) It continues to be a nest of cesspools as it was a dozen years ago.

(*Mr. Michael.*) It does not join on to the metropolitan system.

(*Mr. Lumley Smith.*) I am told that on other occasions this witness took some other samples which were afterwards submitted to some other gentlemen. I have not the actual particulars of them now; but perhaps, if it is necessary to bring further proof of where they were taken, the Commission will allow me to recall this witness. I have not the materials now.

5199. (*Mr. Bidder to the witness.*) Have you taken samples on several other occasions?—Yes; continually for many years.

5200. During those years you have taken many samples of water and mud, and sent them to different gentlemen for analysis?—Yes, as directed by the medical officer.

5201. Besides those which you have mentioned?—Yes.

5202. (*Colonel Ewart.*) You mentioned the year 1880 as rather an exceptional one, I think; you said that the river was black and disagreeable?—Yes.

5203. Do you recollect whether there was anything exceptional about that year; you spoke of the month of July; had there been drought?—It was dry and hot.

5204. It had been an exceptionally dry year?—Yes.

5205. Do you attribute the exceptional state of the river to that?—I do.

5206. Are you conversant with what are called the storm overflows?—With many of them; I should say very nearly all.

5207. Have you seen them discharging frequently?—Yes.

5208. At all times of the year?—I have not taken that special notice. I have seen them run without rain, some of them; not in a rainy season; but I have made no notes of that.

5209. Have you noticed anything offensive about them?—Oh, yes.

5210. Whereabouts?—For instance, at Blackfriars and up at Deptford. There you can smell it in the Broadway; that will tell you when that is running without going near it.

5211. Would you draw any distinction between the time of the year, whether it was summer or winter?—In the summer I have noticed it.

5212. Are there any others that you could mention that you have noticed?—No, I cannot say that there are.

The witness withdrew.

(*Mr. Bidder.*) The witness has told me that the samples are not all recorded in this book, and that he has another book in which many of them are recorded. I presume that there will not be any objection to his coming again with the records of all the samples that he has taken within the last year or two.

(*Chairman.*) He will bring such books as Mr. Lumley Smith advises.

(*Mr. Lumley Smith.*) Certainly, my learned friend shall see everything. The Commission desired yesterday to have evidence with regard to the eel scoots from some one who is actually in the trade. We have the captain of a Dutch eel scoot, who will be leaving at the end of this week; so we will take him now.

Captain JAN VISSER called in, examined by Mr. BALFOUR BROWNE.



5213. How old are you?—51.

5214. You are a Dutchman?—Yes.

5215. What part of Holland do you belong to?—I belong to close to Harlengen, in Friesland.

5216. And I think you are the captain of a Dutch eel vessel?—Yes.

5217. How long have you been in the trade?—Since the year 1858.

5218. In 1858 were you in the habit of coming up the Thames with eels?—Yes.

5219. In 1858 how far up the Thames were you in the habit of coming?—We generally came in the first spring of the year to Erith till about March or April. Then later in the year we shifted them a little further down.

5220. In the spring you lay at Erith, and when it came to be summer you shifted your boat lower down?—Yes.

5221. Why did you do that?—Only through the bad water.

5222. And the bad water made it necessary for you to stay further down the river during the summer months?—Yes.

5223. Do you remember the condition of the river in the years 1866 and 1868?—Yes.

5224. Was it worse then than it had been in 1858?—Yes; it was getting worse and worse almost every year.

5225. In those years did you find it necessary to go further down the river still?—Yes.

5226. Where did you lie in those years?—We lay at Hole Haven Creek in the spring as we do now.

5227. That is where you lie now, is it not?—Yes.

5228. And you tell the Commission that you lie at Hole Haven Creek both in the spring and summer?—Yes.

5229. Is it owing to the condition of the water higher up the river that you have had to go lower down still?—Yes.

5230. Can you tell the Commission whether eels could live in the water below Woolwich?—No, not below Woolwich. Between Erith and Woolwich is the worst part of it.

5231. How do the eels come up to London from Hole Haven Creek?—In the watermen's boats; in boxes. We wet the boxes pretty well and put eels in them, and then they go up dry in boxes.

5232. In that way they go up to Billingsgate?—Yes.

5233. Can you at any time of the year bring the eels up in your boat to London?—No.

5234. Can you tell the Commission what the value of a cargo of eels may be?—That is all according to what the market is. Sometimes it is a low market, and sometimes it is a high market; it varies from 500*l.* to 800*l.* sterling.

5235. (*Sir John Coode.*) I suppose you bring the catch of several boats?—One vessel carries about 10 tons.

5236. And the catch of how many boats will that represent?—I do not know, I am sure, because we are only the same as traders.

5237. You do not take the cargo direct from the fishing boats, do you?—Sometimes we do, and sometimes we do not.

5238. (*Mr. Balfour Browne.*) It would be a very serious matter if you lost the whole of that cargo?—Yes.

5239. And I understand you to tell the Commission that you now cannot bring that cargo up through the foul water at Woolwich to London, but you are obliged to have the eels packed in boxes and brought up by watermen?—Yes.

Cross-examined by Mr. MICHAEL.

5240. When you were in the habit of stopping at Erith in the summer, where did you stay with your boat in the other part of the year?—We do not stop now.

5241. But in 1864 I mean?—Then we lay just below Erith and sometimes just above Erith.

5242. How far were you obliged to go at that time below Erith in the hot weather?—Then we had to shift them at Gravesend. Sometimes for two or three weeks we might shift them down at Greenhithe, and then we shifted them at Gravesend.

5243. At that time did you take the fish out of the well of your boat and put them into boxes for transmission to Billingsgate?—Yes; so we did when we were lying at Gravesend.

5244. That is 18 years ago?—Yes.

5245. Then that was the practice at that time in the same way as it is now?—Yes, just the same.

5246. But is it not the fact that at the present time, in the colder portion of the year, eels are taken in the wells of the boats to Billingsgate without changing them into boxes?—That is only in the first spring of the year, or in the latter part of the year when we have plenty of rain water. At this time of the year we have generally got plenty of rain water. Then we always reckon that we have seven hours ebb tide and five hours flood tide; and then we have more water coming down from above London than there is on the other side coming up. The more rain water there is, the purer the river will be.

5247. At that time of the year you are enabled to take the fish in the wells without changing your cargo into boxes?—I do not come up with my whole cargo; I come up with part of my cargo during the winter.

5248. During the winter and spring you are enabled to bring part of your cargo up to Billingsgate without changing it into boxes?—Yes, part of the cargo.

5249. Do you not do the same thing in this very month of November?—Now I come up with my cargo.

5250. Do you know that on the 14th of this very month (I do not know whether you have done it yourself) boats have taken the whole of their cargo up in the well without changing any of it into boxes?—Very likely.

5251. Therefore, in the spring months when there is a good deal of water, you are able to do it, and at this time of the year also, you are able to do it in the same way?—Yes.

5252. In the summer-time do you change the whole of your cargo into boxes, or do you take any portion out in the summer?—In the summer-time when the water is bad the whole cargo is brought up in boxes.

5253. What did you do 18 years ago in the summer-time; did not you change it into boxes in the same way?—Yes; 18 years ago we did.

5254. In 1858 what did you do?—In 1858, in the first spring of the year, when we were lying up in Erith, we brought them up in pots until April.

5255. I am going back to the time when you first commenced the trade here; that is 24 years ago; then you were obliged to change your cargo into boxes at some times of the year in order to take it to Billingsgate?—Yes.

Re-examined by Mr. LUMLEY SMITH.

5256. Do you happen to remember where the bad water was 24 years ago?—It was all here in London.

5257. When any of the cargo is brought up in the hold is it brought up by a tug or is it brought up by a sailing boat?—By a tug.

5258. And it passes very rapidly through the water?—Yes; the quicker it goes through the water the better, because when we have to stop too long between Barking and Woolwich, then we have a chance to kill all our cargo.

5259. What would kill it?—The water.

Examined by the COMMISSION.

*Capt. Van Visser.*

29 Nov. 1882.

5260. (*Chairman.*) Are all the eels that you bring over from Holland alive?—Yes.

5261. Then how is it that you send up part of your cargo?—We cannot sell the full cargo in one market day.

5262. Then you send one part one day and another part another day?—Yes.

5263. So that in that way you send the whole of the cargo?—In the summer-time all the cargo.

5264. And in the winter-time what do you do?—In the winter-time we lie here like I have been lying here this time.

5265. Do you not send it up to market?—No; then the people come aboard and buy it off our deck just the same as in summer.

The witness withdrew.

Mr. HENRY SPADACCINI called in, and examined by Mr. LUMLEY SMITH.

*Mr. H. Spadaccini.*

5266. I believe you are one of the inspectors of the Port of London Sanitary Authority?—I am.

5267. I think that at one time you were a mate on one of the General Steam Navigation Company's ships?—I was for four years.

5268. How long have you been an inspector of the Port of London Sanitary Authority?—Since the 1st of July in this year.

5269. How long have you known the river?—I have been at sea over 15 years, sailing from London.

5270. As mate of a General Steam Navigation Company's ship, were you on a ship that went abroad?—I have been on several vessels; some of them went to Hamburgh and some to Bordeaux.

5271. Have you had an opportunity of examining the Thames?—I have had a good opportunity since I have been inspector; and before that I had a good opportunity of seeing the water, but not of examining it closely.

5272. Now I come again to what you have seen since you have been inspector; during the time that you have known the Thames have you noticed any change in the river?—I have not noticed any particular change, because as a boy, I did not take much notice of the state of the river; I had not noticed any difference until during the last 10 years.

5273. Have you noticed it at all during the last 10 years?—During the last 10 years I have.

5274. What is the nature of the change that you have seen?—I have noticed the river being in a very foul state very often. When I was mate in the service of the General Steam Navigation Company I had many opportunities of seeing it, going up and down, and I have heard remarks passed about it by the passengers and others on board on many occasions.

5275. You took some samples, did you not, from the river at Barking from the 28th of July to the 29th?—At Barking I did.

5276. Did you take them every hour from noon on July the 28th to 11 o'clock the next morning?—I did.

*The witness handed in the following paper:—*

TABLE B.

High Water, London Bridge, 11.52 a.m.

PARTICULARS of SAMPLES of SEWAGE, &c. taken at NORTHERN OUTFALL.

| No. | Date and Hour. | | Quality of Sewage. | State of Tide. | Remarks. |
|---|---|---|---|---|---|
| 1 | July 28th | Noon | Diluted | First of the ebb. | Sewage running out strongly; commenced to do so nearly a quarter of an hour before barque "Sloboda," of Trieste, lying in line with outfall, swung to ebb tide, very strong smell; sewage running strongly. |
| 2 | „ | 1 p.m. | do. | 1st hour's ebb Sewage running strongly. | |
| 3 | „ | 2 „ | do. | 2nd hour's ebb Sewage running slowly. | |
| 4 | „ | 3 „ | do. | 3rd „ | Sewage running so slowly as not to be perceptible on surface. Arches uncovering. |
| 5 | „ | 4 „ | Pure - | 4th „ | Arches uncovered three feet. Sewage running out at rate of one knot per hour. |
| 6 | „ | 5 „ | do. | 5th „ | Seven inches of sewage on sill (which is between 65 and 70 feet wide), running out at rate of one knot per hour. |
| 7 | July 28th | 6 p.m. | Pure - | 6th hour's ebb<br>6.45 p.m. Barque "Elsboda" swung to flood tide. | Five inches of sewage on sill, following from Nos. 1, 2, 8, and 9 arches at one knot per hour, and from other five arches at half knot per hour.*<br>Sewage running out from Nos. 1 and 9 arches at a knot per hour, and from remaining seven arches at half a knot to three-quarters; wind very light from southward and eastward. |
| 8 | „ | 7 „ | Diluted | 1st of the flood. | Sewage flowing from end arches and mixing with water of flood tide. From noise inside the arches would infer that a considerable discharge was still going on. |
| 9 | „ | 8 „ | do. | 1st hour's flood. | Large patches of sewage deposit becoming detached from bank to eastward of outfall, and floating up the river with the flood tide. |
| 10 | „ | 9 „ | do. | 2nd „ | A strong smell of sewage noticeable. |
| 11 | „ | 10 „ | do. | 3rd „ | Smell of sewage still present, but weaker. |
| 12 | „ | 11 „ | do. | 4th „ | Do. do. |
| 13 | „ | Midnight. | do. | Nearly high water 0.24 a.m.; high water London Bridge 0.35 a.m. Barque in offing swung to ebb tide. | Strong ripples showing in moonlight that a great amount of sewage was being discharged. Barque in offing still swung flood. |
| 14 | 29th | 1 a.m. | do. | 1st hour's ebb. | Sewage running. |
| 15 | „ | 2 „ | do. | 2nd „ | Not as great a discharge as same tide last time. |
| 16 | „ | 3 „ | do. | 3rd „ | Arches nearly uncovered. Sewage running. |
| 17 | „ | 4 „ | Pure - | 4th „ | Arches uncovered. Sewage pouring out at rate of more than two knots an hour. |
| 18 | „ | 5 „ | do. | 5th „ | 15 inches of sewage on sill running out with great force, say, from four to five knots an hour. |
| 19 | „ | 6 „ | do. | 6th „<br>6.45a.m. water commenced to rise on shore. | Sewage flowing out at rate of nearly two knots an hour, water in river one foot below sill. |
| 20 | „ | 7 „ | do. | Low water<br>7.35 Barque swung to flood. | Barges in offing swung athwart. Sewage running out at the rate of one knot per hour over edge of sill.<br>7.35. Sewage running out at a knot an hour over edge of sill. |
| 21 | „ | 8 „ | Diluted | 1st hour flood | Arches uncovered three feet. considerable noise inside arches similar to what has been going on during discharge of sewage. I consider there was sewage flowing when this sample was taken. Patches of sewage deposit floating up with flood tide on bank to eastward of outfalls. |
| 22 | „ | 9 „ | do. | 2nd „<br>Arches covered. | |
| 23 | „ | 10 „ | do. | 3rd hour flood | — |
| 24 | „ | 11 „ | do. | 4th „ | — |

* Sewers are numbered from above.

5277. Does your book contain entries of the hours and the state of the tide and your remarks?—It does; the entries were made on the day following the days on which I took the samples.

5278. The entries were made, I presume, from notes?—Yes.

5279. Will you tell us exactly where you were posted when you took the samples?—As near as I could get to the outfall when the water got low. When first I commenced to take the samples it was high water; then I got in the place where I saw the sewage rising amongst the other water of the river.

5280. I see that high water at London Bridge is stated to be at 11.52 on that day?—Yes.

5281. Then you began at noon?—Yes, the first sample I took at noon.

5282. That would be the first of the ebb?—The first sample was taken on the first of the ebb.

5283. I see your remark is this; "Sewage running "out strongly, commenced to do so nearly a quarter "of an hour before barque 'Elsboda of Trieste' lying "in line with outfall swung to ebb tide," is that correct?—These entries in my book I made myself on the day following the day on which I took my samples, from notes which I took then.

5284. With regard to that barque "Elsboda," did you notice her moored in the river?—I did; she was anchored immediately off the outfall.

5285. She did not swing to the ebb tide till a quarter of an hour after the sewage had commenced running?—Nearly a quarter of an hour after the sewage had commenced running. The sewage commenced running sometime before 12 o'clock, but the first sample was taken at 12 o'clock. I did not note the exact time when I noticed it first running, nor did I note the exact time when the barque swung.

5286. (*Sir John Coode.*) You are speaking of its being high water at London Bridge at 11.52; it would be high water here earlier?—

(*Mr. Michael.*) About 40 minutes.

5287. (*Sir John Coode to the witness.*) Does it agree with your experience that it is high water here 40 minutes earlier than it is at London Bridge?—I do not think I ever noticed that the difference was 40 minutes.

5288. (*Mr. Lumley Smith,*) At noon you took the first sample?—I did.

5289. Are you able to tell when the sewage commenced running out?—I cannot tell the time when the sewage commenced running out; it commenced before 12 o'clock.

5290. But you do not know how long it commenced before 12 o'clock?—No. I arrived there at, I should think, 20 minutes to 12.

5291. When did you notice this barque begin to swing?—The first sign of the sewage that I saw was nearly a quarter of an hour before the barque swung. This was all before 12 o'clock.

5292. Then would the barque begin to swing as soon as the tide began to ebb?—Undoubtedly, as there was no wind.

5293. Did you notice whether the sewage went up or down the stream when it came out, or what became of it?—I did not notice that.

5294. At any rate the sewage was running out before the barque swung?—Before the barque swung the sewage was running out.

5295. At 3 o'clock, three hours after you made the first observation at noon, your remark is, "sewage "running so slowly as not to be perceptible on sur- "face. Arches uncovering." When the sewage begins to flow out, when the outfall first opens, does it come out under water or above water?—Under water.

5296. How are you able to tell that the sewage is escaping?—By the difference in the water, and not only by the difference in the water but by the smell. It was so bad at 12 o'clock that day that it made me feel sick, and I was obliged to row the boat away to some distance.

5297. Is there anything physical to show that the sewage is escaping?—There is a difference in the colour of the water; it is quite black, a blue black colour.

5298. When you say that the sewage was running out so slowly as not to be perceptible on the surface, there again it would be escaping under water, I presume?—I think so.

5299. What are the arches which you say were uncovering?—Nine arches where the sewage comes out were just uncovering.

5300. I see that at 4 p.m. you first get the quality of the sewage "pure," do you mean pure water or pure sewage?—That is pure sewage, I may have had pure sewage before, but I could not be certain of it.

5301. At 4 p.m. your remark is "arches uncovered "three feet. Sewage running out at rate of one knot "per hour." Were you able at that time to see the sill?—The boat was in on the sill, and I got the samples as the sewage poured out from under the arches.

5302. Why do you say that it was pure sewage?—Because I know it was pure; it was pouring out between the sides of the sewer.

5303. Your bottle was full of the contents of the outfall?—It was.

5304. How do you get your one knot per hour; is that a matter of estimate?—That is only a matter of estimate.

5305. Then I see that at 5 o'clock you get seven inches of sewage on the sill, and it has then been running out about five hours?—Yes.

5306. And I see you say that the sill is between 65 and 70 feet wide?—That is only an estimate too, because I had no means of measuring it.

5307. At 6 o'clock you say there were five inches of sewage on the sill flowing from only four of the arches, viz., arches Nos. 1, 2, 8, and 9, at one knot per hour, and from the other five arches at half a knot per hour: why does it flow more strongly from some than from others?—I could not tell.

5308. Then we come to another entry in which you say at 6 45 p.m. the barque "Elsboda," swung to the flood tide; that you noticed, I suppose?—I did.

5309. The water would be coming up stream then?—Yes, the water would be coming up stream when she swung.

5310. Have you any note showing when this sewage ceased to flow out? At 7 o'clock I see you say that it was diluted, and that the sewage was flowing out from the end arches, and mixing with the water of the flood tide, and that you would infer from the noise inside the arches that a considerable discharge was still going on. Will you describe what you mean by the noise within the arches?—Whilst the water was very low on the sill the boat was grounded close to the arches and there was a noise going on all the time that the sewage was flowing out. After I ceased to see the sewage flowing into the river this noise still continued, so that I inferred that the discharge was still going on.

5311. At eight o'clock you say the arches were uncovered 18 inches and that large patches of sewage deposit were becoming detached from the bank to the eastward of the outfall and floating up the river with the flood tide; those, I suppose, were patches that were on the banks?—Yes, patches lighting off the banks.

5312. When the water was low they remained on the banks?—On one particular bank. This is a bank which lies at the eastern or lower side of the outfall; the greater part of this bank is covered over with small pieces of newspaper that evidently came from the sewers, that drew my attention to it first. They were small pieces; it would take ten of them to cover my thumb nail. When the tide rose some patches seemed to rise up and flow up with the flood tide, and they went up stream. That happened on both tides.

5313. At nine o'clock I notice you state that there was a strong smell of sewage noticeable; were you able to tell whether it was still flowing out?—I could not tell you.

*Mr. H. Spadaccini.*

29 Nov. 1882.

5314. But you smelt the smell?—Yes.

5315. Now I will take you on to past midnight at nearly high water when you say that the barque in the offing swung to the ebb tide with its head southerly; in your remarks you say that there were strong ripples showing in the moonlight that a great amount of sewage was being discharged, and then you say "Barque in offing still swung flood." You judged by the ripples that there was sewage being discharged?—There is no doubt about the sewage being discharged; there was a strong smell and there were ripples or eddies.

5316. Would it go up or down?—It would go up the river; all the sewage that was being discharged would, I think, go up the river.

5317. (*Mr. Michael.*) But did you observe it?—I did not observe it, it was too dark.

5318. (*Mr. Lumley Smith.*) Did you judge by the ripples that the sewage was going up?—No, I did not judge by the ripples that the sewage was going up, but I judged by the way the barque was swung, that the sewage must be going up the river.

5319. I need not take you through all your remarks on the rest of your observations; but going on to seven o'clock, I see you have "low water. Barges in offing swung athwart." What is the meaning of that?—That means that there was no tide where the barges were; that they were lying with their sterns towards shore.

5320. That would be dead low water?—Yes. The water commenced to rise on the shore previously to this. The stream had ceased running down the river.

5321. At the time when the stream had ceased running down the river your note is that sewage was running out at the rate of one knot per hour?—That is true, it was running out over the edge of the sill.

5322. Is the sill visible then?—Yes, quite visible; the whole of the platform is visible then. I do not know what depth of sewage would be running over it, but there was a certain amount running down into the river. The water in the river was below the sill at this time, and the sewage was falling over the edge of the sill into the river. This was about the time when the barges swung athwart.

5323. Do you happen to remember whether it was rainy weather or dry weather about this time?—The day in question was a dry day; we had no rain at all; but I do not remember what was the state of the weather generally.

5324. You had been there on this occasion up to seven o'clock in the morning since noon of the previous day; are you able to say that there had been no storm of rain at all, but that it was a dry day?—There was no storm where we were; it was dry all the time. There was a little fog during the night.

5325. But at seven o'clock, in the morning there would be no unusual storm or anything to keep it running, so far as you know?—No.

5326. But you say that at low water there was sewage coming over the sill?—There was.

5327. On the first hour of the flood I see that you again make the remark, that there was a noise inside the arches, and that in your judgment there was sewage flowing up?—Yes.

5328. On this day it was exceedingly disagreeable where you were; you were just at the outfall?—Yes, close in on the sill; the boat was grounded on the sill for some time.

5329. During those 24 hours the opening of the sluices would happen twice, would it not?—It would.

5330. On either of those occasions in your judgment did the outlet commence before the stream had begun to go down the river?—On both occasions I believe it did.

5331. On both occasions you believe that the sewage came in from the outfall before the stream had commenced to go down?—Yes.

5332. It would naturally go up with the stream?—It would go up with the stream.

(*Mr. Michael.*) We have already had it, that for 40 minutes before the turn of the tide, there is a back current which takes all the water down on the Barking shore.

5333. (*Mr. Lumley Smith, to the Witness.*) Is that your view?—I never noticed it.

(*Mr. Abernethy.*) Is that on the north or the south side?

(*Mr. Michael.*) On the Barking side.

(*Mr. Lumley Smith.*) With regard to this witness again, I believe he took some other samples and, if necessary, I must ask leave to recall him.

Cross-examined by Mr. Michael.

5334. What did you do with the samples that you took upon this occasion?—I took them to the Port Sanitary office at Greenwich.

5335. What did you do with them there?—I did not do any more with them, I left them at our office.

5336. What did you take them in, in glass bottles?—In glass bottles.

5337. Were they all the same size?—All the same size.

5338. What did you do with them when you took them?—I put glass stoppers in the bottles, and tied them down with twine.

5339. Were they numbered consecutively 1, 2, 3, 4, and so on?—They were all numbered the same as they are in the notes.

5340. I presume you have taken a great many other samples, have you not, besides these?—Yes, I have taken some samples since then.

5341. Were these the first?—These were the first.

5342. How many samples have you taken altogether since you took these?—I do not know exactly how many samples I have taken since then.

5343. Have you kept a record in your book of all the samples that you have taken?—I am not sure that I have.

5344. But have you kept any record of any samples that you have taken to the office in these glass bottles?—There is a record taken, but I am not sure whether it is in this book or not.

5345. Could you bring us the record of the whole of the samples?—I could bring it.

5346. Would you be kind enough, when you come again, to bring the record of all the samples which you have taken with the dates in the same way?—I will.

Examined by the Commission.

5347. (*Sir John Coode.*) Are we to understand that the arches are covered as early as the second hour of the flood, as this note seems to indicate?—If the note says so, it is so.

5348. The notes say, "second hour arches covered," that is at 9 a.m.; are they covered at about that period of the flood?—I should think they were; the tide rises very quickly.

5349. You told us just now that it was low water slack at 7 a.m. when the barges were lying in the stream. Am I right in gathering from a note here that the barge swung to the flood at 7.35, and that at 7.35 the sewage was running out at the rate of a knot per hour?—Yes.

5350. Then the conclusion which we are to draw from that is that at 35 minutes after low water slack, and after the barque had turned and swung to the tide, the sewage was running out over the sill?—Yes, the sewage was pouring out over the sill at the rate of a knot per hour.

The witness withdrew.

CAPTAIN RICHARD MARSDEN called in and examined by Mr. BALFOUR BROWNE.

5351. I think you are harbour master for the district of Gravesend?—I am.

5352. How long have you been the harbour master of Gravesend?—About one year.

5353. For three years before that time, I think you were harbour master of the Limehouse district?—I was.

5354. I believe that while you were at Limehouse you very often took Captain Fitzgerald's duty in his district, which is between Greenwich and Greenhithe?—Yes.

5355. And I believe, having had those opportunities you have made various observations upon the state of the river at various times?—I have.

5356. Have you your notes of those observations with you?—Yes.

*The witness handed in the following paper:—*

"REMARKS and NOTES on the FOULING of the RIVER, and ACCUMULATION of MUD in certain parts of the RIVER. From CAPTAIN MARSDEN, HARBOUR MASTER, GRAVESEND.

The fishermen state that they used to trawl for shrimps up Long Reach, and even in Erith Rands good fish were to be caught. Now the bottom is so muddy and the water so foul, that nothing is to be found there.

The eel schoots cannot lie in the river above Hole Haven, and only then inside the haven, as, by the shoal to the westward, the ebb tide is prevented finding its way in, and they only get the *flood* tide water. And when they tow up to London Bridge they shut their valves to prevent the impure water getting to their fish.

An anchor lost in Long Reach is very seldom recovered on account of the mud, and the decks of ships anchoring there are much fouled by the filthy mud adhering to the cable.

The fishermen all speak to the foul condition of the river, and adduce in evidence, that the shrimping boats are all now fitted with boilers to boil the shrimps on board, as they are not able to bring them up to Gravesend *alive* in the wells of the boats.

EXTRACTS from JOURNAL concerning the BAD STATE of the RIVER at various DATES.

June 24th, 1879.—Being soon after I was appointed deputy harbour master of Port of London, perceived a large quantity of sewage coming into river from Ratcliffe Cross outfall. And this was constantly the case whenever there was rain.

September 3rd, 1879.—Being on duty on central station, passing the southern outfall, found the water very filthy with a horrible smell.

February 21st, 1880.—On duty on central station. Observing the drift of the current in Halfway Reach for several days, and having to lean over the side of the boat, and being close to the water, the smell was most offensive and sickening.

July 24th, 1880.—Attending a launch at Messrs. Edwards, Millwall, three-quarters flood, the water was very foul, and off Cubitt Town the stench and state of the river was very bad, a black slimy appearance being on the water.

This was the worst state I ever saw the river in.

September 1st, 1880.—On duty in central station, one quarter ebb off northern outfall, observed the water was in a very bad state, black and stinking horribly. This continued all down Barking Reach.

September 2nd.—Quarter ebb very foul, and stinking fluid coming out of the northern outfall.

September 8th.—River very bad in Halfway Reach; water black, and smell sickening. This continued right up to Blackwall.

September 10th.—Water very bad in Erith and Halfway Reaches.

September 29th.—River very much charged with sewage, worst coming from northern outfall.

October 26th.—Ratcliff Cross outfall half ebb pouring out a great quantity of sewage into river; weather rainy.

April 20th, 1881.—Third storm outlet at Ratcliff Cross.

September 2nd.—Central station. Water much discoloured at sewage outlets.

September 5th.—Found water very foul and stinking from Northern outfall to Erith.

RICHARD MARSDEN,
Harbour Master,
July 18th 1882. Gravesend."

5357. First of all, will you tell me what you observed the condition of the river to be on the 24th of June 1879; I think that was soon after you were appointed harbour master at Limehouse?—Yes, it was. On that day in the morning (I could not give the hour) I perceived a large quantity of sewage coming into the river from Ratcliff Cross outfall.

5358. Have you had an opportunity of observing a similar overflow or outflow upon various other occasions?—Yes, constantly whenever it rains.

5359. Whenever it rains there is an overflow from that outlet?—Yes.

5360. (*Sir John Coode.*) Can you give the size of this outfall, because it is rather material to know whether it is large or small?—It is about four feet broad by above two feet deep, I should think, as far as I could tell.

5361. (*Mr. Balfour Browne.*) Upon the 26th of June at 11.30 on approaching the storm outlet at Ratcliff Cross, I think you observed something?—That I think was a report that I made to the Board.

5362. (*Mr. Michael.*) To whom did you report?—To the Board of Conservators.

(*Sir John Coode.*) There seems to be neither the hour of the day nor the state of the tides in these notes.

(*Witness.*) It was the ebb tide. I can tell you that much.

5363. (*Mr. Balfour Browne.*) And you said it was in the morning, but you could not say the exact hour. It was ebb tide when you observed what you have told the committee?—Yes.

5364. And I understood you to say that you had seen that storm overflow in action at various other times, in fact, whenever it rained?—Yes.

5365. On the 26th of June at 11.30 a.m. you say you observed something; can you tell the Commission what was the condition of the tide at that time?—The tide was three-quarter ebb.

5366. What did you observe?—Approaching the storm outlet at Ratcliff Cross, I encountered a great quantity of sewage matter of the worst possible kind issuing from that outlet.

5367. (*Chairman.*) Is this a memorandum that you made at the time?—This is a report that I made to the Thames Conservancy Board.

5368. Did you make a memorandum upon this subject at about the same time that you observed this?—Yes; this is from what I observed.

5369. What is the date of the paper that you are referring to?—The 17th of July of the same year.

5370. That is nothing but a copy. Have you your own books?—No; there would be nothing in the book about this.

5371. You wrote that paper from memory?—Yes.

5372. Looking at that paper you are able to say that the facts which you have there are quite correct?—Quite correct.

5373. (*Mr. Balfour Browne.*) It was three-quarter ebb when you observed a great quantity of sewage matter of the worst possible kind issuing from this Ratcliff Cross outlet?—It could not have been worse if we had been in the sewer itself. It was just before low water, and as a natural consequence all

*Capt. R. Marsden.*

29 Nov. 1882.

this excrement would be carried up the river with the flood tide floating and being deposited in the higher reaches.

5374. (*Sir John Coode.*) Had there been heavy rain on that day?—There had been rain. I do not say it was heavy rain.

(*Mr. Michael.*) These outlets cannot act without there has been heavy rain.

(*Mr. Balfour Browne.*) That is one of the questions in dispute.

(*Sir John Coode.*) It was stated by one of the witnesses that they did act, and that he had seen them act when there was no rain.

(*Mr. Michael.*) The Commissioners themselves will see the storm outfalls and will see that it is impossible.

5375. (*Mr. Balfour Browne to the Witness.*) I think you reported it to the sanitary inspector?—I met him on the river in his launch and called his attention to it, and he went over there and took samples.

5376. Who is the sanitary inspector?—Lewis.

5377. On the 3rd of September 1879, I think you were on duty at the central station?—Yes.

5378. Where is the central station?—The central station is from Greenwich to Greenhithe.

5379. Then I suppose you were taking Captain Fitzgerald's duty?—I was.

5380. What did you observe upon that occasion?—Passing the southern outfall I found the water very filthy with a horrible smell.

5381. Can you tell what was the time of day and the condition of the tide?—No, I did not make any note of that.

5382. On the 21st of February 1880, I see you made a note?—Yes, I was on duty at the central station again then. Observing the drift of the current in Halfway Reach for several days and having to lean over the side of the boat, and being close to the water, the smell was most offensive and sickening.

5383. (*Mr. Michael.*) How near were you to the outfall?—I was passing the outfall.

5384. (*Mr. Balfour Browne.*) On the 24th of July 1880, I think you attended a launch at Messrs. Edwards; what have you to say about that?—It was three-quarter flood at that time, and the water was very foul, and off Cubitt Town the stench and state of the river was very bad, a black slimy appearance being on the water. This was the worst state I ever saw the river in.

5385. Then I think you as harbour master made a report of that to the Conservancy?—Yes.

5386. On the 1st of September 1880 you were again on duty at the central station?—Yes.

5387. What was the condition of the tide?—At a quarter ebb off the northern outfall, I observed that the water was in a very bad state, black and stinking horribly. This continued all down Barking Reach.

5388. The next day I think you again observed it?—On the 2nd of September I observed again at a quarter ebb a very foul and stinking fluid coming out of the northern outfall.

5389. On September the 8th what did you observe?—On September the 8th the river was very bad in Halfway Reach; the water was black, and the smell sickening. This continued right up to Blackwall.

5390. Then on September the 10th, two days afterwards you were on duty again?—Yes, and on that date the water was very bad in Erith and Halfway Reaches.

5391. What was the condition of the river on September the 29th?—The river was very much charged with sewage—the worst coming from the northern outfall.

5392. Have you a record for October the 26th?—On that date the tide being half ebb the Ratcliff Cross outfall was pouring out a great quantity of sewage into the river. It was rainy weather on that occasion.

5393. Then I see that you have a note for April 1881?—That was a report that I made to the Board. I observed a third storm outlet being made on the shore.

5394. Can you give my learned friend the exact date?—I cannot now.

5395. Then on the 2nd of September 1881, I think you were on the central station again?—Yes.

5396. What was the condition of the river then?—The water was much discoloured at the sewage outlets.

5397. On September the 5th of the same year what did you find?—I found the water very foul and stinking from the northern outfall to Erith.

Cross-examined by Mr. Michael.

5398. Have you ever noticed when the sewage was being discharged, either from the northern outfall or from the southern outfall, that the water was not discoloured by the sewage coming into it?—No, I cannot say that I have. I think it is always discoloured.

5399. I suppose it is a necessary consequence, is it not, of the outfalls being there and discharging sewage that it would discolour the water?—I do not know that it is a necessary consequence.

5400. Have you ever seen it when it did not discolour the water?—I have seen the river very much cleaner at some times than at others.

5401. With the same quantity of sewage being discharged?—I cannot say about the quantity of sewage.

5402. You are not able to say on all these occasions when you saw the storm outfalls discharging, whether there had been a storm or a heavy storm of rain previously?—I could do so by referring to my journal.

5403. You do not know, I suppose, the construction of the outfall?—I do not.

5404. I should be glad if you would furnish the Commission with a statement of the weather as you may have recorded it?—Yes, I will give you all that.

5405. When you speak of the water being of this bad smell and appearance, it has always been somewhere near the outfall itself?—Not always; it is so down in Erith Reach and up at Blackwall; neither place is near the outfalls.

5406. Do you mean as to the appearance or as to the smell of the water?—Of course the smell is not so bad at Erith and at Blackwall, as it is just close to the outfalls; but still it is very bad.

5407. How far do you say that this bad smell, when you have noticed it worst, has extended up and down the river?—I have noted it down as far as Erith and up as far as Blackwall.

5408. Have you ever noticed how far that smell extended over the land?—No.

5409. You are not able to give the Commission any information as to that?—No.

5410. You say that it is part of your duty to be on the river; how many hours do you spend on the river?—Several hours daily; sometimes four, sometimes five, and sometimes six.

5411. Are you brought much in contact with persons who are obliged to remain many hours daily on the river in the pursuit of their avocations?—Yes fishermen and other people of that sort.

5412. What is the general condition of their health so far as you have observed it?—I do not think there is much the matter with them; they look a pretty healthy set of men.

5413. Has it ever been brought to your attention that any special form of disease or difficulty in carrying on their employment has affected those persons who are for many hours every day on the waters of the Thames?—No.

Re-examined by Mr. Balfour Browne.

5414. Is the smell that you have at Blackwall and lower down at Erith the same smell that you have at the outfalls, only fainter ?—Just so.

*Capt. R. Marsden.*

29 Nov. 1882.

Examined by the Commission.

5415. (*Dr. de Chaumont.*) How long have the men in your employ been in that service ?—A long time—several years.

5416. What is the average length of time that a man remains there ?—Some of the men have been seven and eight and ten years, and some of them even twenty years.

5417. You do not know of any who have been obliged to give up on account of sickness ?—I do not think so.

The witness withdrew.

Mr. George Robert Showell called in, and examined by Mr. Lumley Smith.

*Mr. G. R. Showell.*

5418. You are I believe the master of the steam launch "Hygeia" in the service of the Port of London Sanitary Authority ?—Yes.

5419. Have you been for a good many years on the river ?—Yes.

5420. How many years ?—From the time of my apprenticeship; something like 27 years; but I was born and brought up alongside the water.

5421. How old are you now ?—41.

5422. And you have known the river all your life ?—Yes.

5423. I will ask you one or two general questions. Have you noticed any foulness in the condition of the river ?—Many times.

5424. At what times do you find it worst ?—I have seen it on the low water round the bight of East Greenwich.

5425. What have you seen there ?—Other than water.

5426. What is it ?—It is something quite otherwise than water; what I should term sewage.

5427. That you have seen up at East Greenwich, which is above the outfalls, I think ?—Yes.

5428. It is the bight a little below Greenwich itself ?—Yes.

5429. First of all have you seen it at Woolwich ?—Yes.

5430. At what time of the tide have you seen it ?—I have seen it on low water on young flood there again, and on high water particularly.

5431. Anywhere else about that neighbourhood ?—Yes, all along there.

5432. In Half Way Reach have you ever noticed the water in a bad condition ?—I have seen it come out and there stop and go no further but hang on to the eddy at the points.

5433. Have you anchored occasionally off either of the outfalls ?—Many times.

5434. Have you been able to see how long they went on discharging there, having regard to the flowing of the tide ?—It is supposition; it was not sightable.

5435. Was there anything that you could judge by ?—I have seen the colour of the water.

5436. From the colour of the water, should you judge that the outflowing was still going on ?—Yes.

5437. How long have you seen that going on ?—I have seen it at about three parts flood, that is to say, coming out about two hours before high water; and then directly the tide has ebbed two hours it has not gone any farther when the wind has been easterly, or even in calm weather.

5438. You mean that the sewage has not gone down the river ?—It has not gone away at all.

5439. But how long with regard to the tide, have you seen the sewage discharging ?—I have seen it discharging when it has been three parts ebb. That is on supposition; it is not sightable.

5440. You are judging by the colour of the water ?—Yes.

5441. And you have seen it discharging till three parts ebb ?—Yes.

5442. Have you ever seen it discharging later than that ?—It is unsightable on account of water lying there stagnating.

5443. Do you remember one occasion on the 16th of November, 1882, that is this month ?—Yes.

5444. You were rowing Dr. Collingridge down, I believe, were you not ?—Yes.

5445. Did you pass the sewer at Barking ?—Yes.

5446. At what time was it high water at London Bridge on that day ?—Something after five o'clock.

5447. I am told it was at 4·15; but what time was it when you were at Barking ?—A quarter past 12 in the daytime.

5448. Were the sewers at Barking discharging then ?—The sewage was running out of three or four pipes, I think, running out fast.

5449. Was the tide flowing or ebbing at Barking ?—It was flowing then. It was low water about 12 o'clock.

5450. Have you sometimes, in navigating vessels, seen them aground ?—Yes. Formerly we used to bring up at the sewer with something like 12 to 14 feet of water, that is above the Powder House just below Crossness. We could lie there in 14 feet of water. That is a respectable distance from the shore.

5451. Now you find mud there ?—Yes.

5452. What sort of mud is it ?—All loose stuff; of course it is a substance.

5453. What substance is that ?—It is a mixture of mud and something else of course.

5454. Do not be so shy about it; what is the mixture ?—I should say that it is sewage intermixed with mud.

5455. What makes you say it is sewage ?—On account of the stink.

5456. What colour is it ?—A kind of blueish black.

5457. Have you sometimes anchored off Crossness ?—Many times.

5458. In what condition has your anchor been when you have pulled it up ?—I have had a sailor up many-times washing the chain as it came through the hawse pipe.

5459. Was it foul ?—It was covered with the same substance.

Cross-examined by Mr. Norman Bazalgette.

5460. Did I rightly understand you to say that on some occasions you have seen the sewage discharged with the ebb, and then stopped by the east wind ?—Yes.

5461. Does the east wind stop the sewage only, or does it stop the tideway ?—The eddy tide and the wind together stop the sewage from running away.

5462. It stops the sewage and the tide too ?—It stops the sewage and the tide too.

5463. I think you said that you had seen the sewage on low water at East Greenwich ?—Yes.

5464. When did you see that last ?—I have seen it this summer.

*Mr. G. R. Showell.*

29 Nov. 1882.

5465. Can you give us any particular date?—I cannot. I have seen it on several occasions.

5466. Have you seen it more than once this summer?—Yes.

5467. How often?—I should say several times.

5468. Two or three times?—More than three.

5469. How long have you known East Greenwich?—All my life, I might say.

5470. Roughly speaking, what was the condition of the water at East Greenwich 20 years ago?—I was born on the edge of the water at West Greenwich, and we could have fish of all kinds at our back premises. I have seen fresh water haddocks there.

5471. Was that 20 years ago?—Yes.

5472. What was the condition of the water at East Greenwich 20 years ago?—Very good. I have seen freshwater haddocks there then.

5473. You are a good deal upon the water, are you not?—Yes, and always have been.

5474. What kind of health do you enjoy?—Generally speaking, I enjoy good health. I get the air from all quarters. I am not confined to one particular place.

5475. Do you find that you enjoy worse health at East Greenwich than at other places?—I am not there at all times. I live at West Greenwich.

5476. But do you find that you enjoy worse health at East Greenwich than at other places?—I cannot say. I am not there long enough to see.

Examined by the COMMISSION.

5477. (*Chairman.*) Have you ever experienced any faintness or sickness when you have noticed these smells?—I have had very unpleasant smells and tastes too from the spray that has gone into my mouth at different times.

5478. Have you felt anything like sickness or faintness?—No, I cannot particularly say that I have.

5479. (*Mr. Norman Bazalgette.*) (*Through the Commission.*) You say you have occasionally experienced an unpleasant taste from the spray?—Yes.

5480. Was that when you have been anchored off Crossness?—When I have been coming right through Halfway Reach head to wind, with a strong wind.

5481. Near the outfalls?—Right through the Reach.

The witness withdrew.

Adjourned to Tuesday next at half past 12 o'clock.

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# TENTH DAY.

## Tuesday, 5th December 1882.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, ESQ. M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.

WILLIAM POLE, ESQ., F.R.S., *Secretary.*

CAPTAIN JOHN FITZGERALD, R.N., called in, and examined by Mr. LUMLEY SMITH.

*Capt. J. Fitzgerald, R.N.*

5 Dec. 1882.

5482. I believe you are a Staff Commander in the Royal Navy?—I am.

5483. What office do you hold?—I am at present harbour master of the central station on the River Thames.

5484. What are the limits of the central station?—The limits of the central station lie between Greenwich and Greenhithe.

5485. How long have you been in that position?—Five years.

5486. During that time have you had considerable opportunities of seeing the condition of the River Thames?—I have, almost daily.

5487. In your opinion has there been any change in the course of the last five years in the condition of the River Thames?—I have only known it for five years, and I could not say what it was before.

5488. In the course of your observations have you noticed any change?—Yes; certainly there has been a change for the worse.

5489. What are the symptoms of the change?—During the years 1880 and 1881 it was very much worse than it was in 1878 and 1879.

5490. I will come to 1880 and 1881 a little more in detail; but what is the nature of the deterioration?—The nature of the water was very much worse in 1880 and 1881. At this moment it happens to be comparatively clear; but during the years 1880 and 1881 the water was very much more discoloured and impure than it was during the years 1878 and 1879.

5491. Have you formed an opinion as to what was the cause of that increased impurity?—My opinion is that it is due to the outfalls at Barking and Crossness.

5492. I believe that in the year 1880 it got very bad, did it not, about the month of July?—It was exceedingly bad in 1880, and not quite so bad in 1881.

5493. Your five years would begin in 1877?—In 1877.

5494. Before the year 1880 did you make any careful observations of the state of the river, or was it merely casual observation?—Before 1880 I did. I am speaking from memory now. I took various notes in my journals from time to time when I made these observations, and I could give, and have already given, the days and dates when they were taken.

5495. In 1880 you took special observations, I believe?—I did. The river was worse than it had been, and I took special observations in 1880, and also in 1881.

5496. (*Mr. Bidder.*) Have you your journals here?—Yes, I have all my journals here.

5497. I should like to see them.

(*Witness.*) Will you kindly give me the date you want?

(*Mr. Lumley Smith.*) The 24th of June 1880.

(*The witness produced his journal.*)

5498. (*Chairman.*) These were entries made at the time ?—These were entries made at the time in my journal, which I keep daily.

5499. (*Sir John Coode.*) And the entries were made day by day ?—Yes. My entry for the 24th of June is, "Smell from the river water most offensive, which "continued the entire day. The stream on flood and "ebb apparently charged with sewage."

5500. (*Mr. Lumley Smith.*) Are these observations all made at the same place ?—No. My district lies between Greenwich and Greenhithe.

5501. They are taken within your district ?—Within my district.

5502. What is your entry for the 25th of June ?—"Smell of sewage pervades the river from Charlton to "Erith quite as bad on the flood as on the ebb tide."

5503. What is your entry for the 26th of June ?—"Smell from the river water still offensive, but not so "bad as yesterday."

5504. I think you have no further entry until the 6th of July ?—That is so. My entry for the 6th of July is, "A very offensive smell from the river water "in lower part of the district, especially in Erith "Reach, although the water was comparatively clear."

5505. What is your entry for the 7th of July ?—"River water smelling very much in Erith and Half-"way Reaches, and a good deal discoloured below "Barking."

5506. What is your entry for the 9th of July ?—"River water much discoloured and smelling badly."

5507. (*Sir John Coode.*) To what point did that last remark refer ?—I have not stated specially in what part. It refers to the district generally.

5508. (*Mr. Lumley Smith.*) What is your entry for the 11th of July ?—"Water strongly impregnated with "sewage, and smelling badly."

5509. (*Mr. Bidder.*) Where is that ?—That is in the upper part, off Woolwich. By the upper part I mean that part which lies between Woolwich and Greenwich.

5510. (*Mr. Lumley Smith.*) What is your entry for the 12th of July ?—"Landed at southern outfall "this day to complain of the state of the river. Was "informed the sluices had been opened at the usual "time, a statement which I was inclined to doubt, "owing to the water below the works being com-"paratively clear and the air free from sewage taint, "whereas in Barking Reach it was the reverse." That was at half-flood, I omitted to say.

5511. On that occasion, then, at half-flood, you found the river, below the works, comparatively clear and free from taint, whereas above it was the reverse ?—Yes.

5512. What is your entry for the 13th of July ?—"River water in a very bad state off Charlton and Woolwich."

5513. What is your entry for the 15th of July ?—"River water greatly discoloured with sewage in "Bugsby and Blackwall Reach, and smelling very "badly."

5514. What is your entry for the 17th of July ?—"The river water to-day, both on the ebb and up to "following half-flood, from Woolwich to Erith, was "in a worse condition than I have ever known it. "The water throughout this part, and from side to "side of the river, was heavily charged with sewage, "and the stench almost unbearable."

5515. That is between Woolwich and Erith ?—Between Woolwich and Erith.

5516. What is your entry for the 18th of July ?—"The river water in Woolwich Reach almost black "with sewage."

5517. What is your entry for the 19th ?—"River "much clearer to-day on surface, but bad inshore."

5518. What is your entry for the 21st ?—"River "water this day fairly clear on surface, but filthy and "stinking underneath, every steamer leaving dis-"coloured water in her wake. Immediately above "Leather-bottle Point the water was nearly black at "the last quarter-flood, covering a surface of nearly a "mile."

5519. Before we pass on, I think Leather-bottle Point is what is called Crossness Point ?—Crossness Point, or Halfway-house Point; it has three names.

5520. Did you find on that occasion that although the water was clear at the top that clearness did not seem to go very deep ?—No, it was only surface water.

5521. And that the steamers turned up fouler water underneath ?—Yes, the steamers turned up fouler water as they passed along.

5522. What entry have you on the 22nd of July ?—"River in filthy condition between Charlton and "Erith, and sewage apparently working its way "higher up the river."

5523. Where is Charlton ?—Just above Woolwich.

5524. (*Mr. Bidder.*) Have you your diary for 1878 ?—Yes (*handing it to the learned counsel*).

5525. (*Mr. Lumley Smith.*) Speaking of your entry for the 22nd of July, "Sewage apparently work-"ing its way higher up the river," is that a matter that you can see with your eyes ?—Yes.

5526. It is not a matter of deduction from the set of the tide merely ?—No, you can see it.

5527. What is your entry for the 23rd of July ?—"River from Charlton to Erith in filthy condition at "low water, and the stench abominable. Water during "the whole flood heavily charged with sewage matter "from side to side, nearly black in some places, and "the river, even at high water, above Greenwich full "of sewage, and the odour disgusting."

5528. What entry have you on the 24th of July ?—"River water on surface at high water a little im-"proved."

5529. What is your entry for the 25th of July ?—"River to-day in a beastly state again; William Tur-"nidge" (that is one of the men belonging to my steamer) "sick; attributes it to the river water."

5530. What is your entry for the 26th of July ?—"At low water to-day the river from Bugsby down "was choke full of sewage. Landing-places and fore-"shore full of it. Stench abominable. The same on "flood. Slightly better at high water, but on the ebb "a strong smell of sewage present right across the "river at Woolwich, and the water getting thicker "as the tide fell."

5531. The quantity of water in the stream would diminish as the tide fell ?—It would.

5532. And you say the water got thicker ?—I meant by that expression "thicker" that there was more suspended matter in the water.

5533. What is your entry for the 27th of July ?—"River water tolerably clear at high water this day; "black streaks and patches visible at first quarter "ebb."

5534. One question upon the subject of these black patches. Can you give the Commission any idea of what they were—what was their size for example, and their appearance ?—The patches varied considerably in size, some were large and some were small. Some were patches of about the size of this room, others were six times as large. They were all over the river.

5535. You mention that they were visible at first quarter ebb; did you form any opinion as to why they became visible ?—I was under the impression that it was the clean water being swept away from the surface and leaving patches of the dirty water underneath.

5536. Those were patches that had been suspended below the surface ?—Yes, that is what it appeared to me to be like.

5537. That is to say, they were not in sight at the full flood ?—They came up on the first quarter ebb, as the clean water was swept away down the river.

5538. Did you examine them at all ?—I did not take any samples of those patches.

5539. You formed an opinion as to what they were composed of ?—Yes; I formed the opinion that it was sewage.

5540. What is your entry on the 28th of July ?—"River water improved off Charlton, but full of

*Capt. J. Fitzgerald, R.N.*

5 Dec. 1882.

" sewage in Barking and Halfway Reaches at half ebb.
" Patches of sewage all over Long Reach and smell-
" ing badly."

5541. What is your entry on the 29th of July?—
" Water in river rather better to-day, owing to the
" prevalence of strong westerly winds. Surface water
" fairly clean and free from smell."

5542. What is your entry on the 30th of July?—
" Water in river continues to improve, but the fore-
" shore and some of the landing-places are clothed
" with sewage mud."

5543. What is your entry on the 31st of July?—
" River water continues to improve."

5544. What is your entry on the 4th of August?—
" Water in the river to-day much improved and free
" from smell, excepting in Halfway Reach."

5545. What is your entry on the 5th of August?—
" River water fairly clean to-day and free from
" smell."

5546. What is your entry on the 13th of August?—
" River water this day smelling badly. Patches of
" sewage visible throughout the district, especially at
" first quarter flood."

5547. Have you read the whole of that?—That is all I can see here.

5548. What is your entry on the 20th of August?—
" Water in river continues to remain fairly clear and
" free from smell."

5549. What is your entry on the 21st of August?—
" Water to-day fairly clear, but smelling badly at low
" water."

5550. What is your entry on the 27th of August?—
" River water throughout the day, both on the ebb
" and flood, smelling strongly of sewage, and black
" patches to be seen in various parts of the river."

5551. That is the last of your observations, I think, about that time?—Yes.

5552. How came you to take these almost daily observations?—The river was so excessively bad at that time that I thought it my duty to take observations daily.

5553 And from time to time you reported?—Yes; I reported from time to time to the Conservators.

5554. I may take it that after August it improved somewhat?—Yes; I went away at the latter end of August. I generally go away then for a month, and another gentleman takes my place, and he took observations, I believe, in my absence during the whole of September.

5555. (*Mr. Balfour Browne.*) We have had Captain Marsden, who took your place?—Yes; he took my place on that occasion.

5556. (*Mr. Lumley Smith.*) Was this a hot time?—In 1880 it was the worst time.

5557. In this particular July that you have been given us, was it hot weather?—Yes, it was hot, sultry weather.

5558. I think you have a note in your book in October?—I was back in October. I have an entry then. "River water charged heavily with sewage to-
" day, especially in Erith and Halfway Reaches. Air
" bubbles visible right across the river."

5559. I think that hot weather came again in the following year, did it not?—In 1881 we had some hot weather.

5560. Did you find a recurrence of the same class of annoyance?—Just the same; it was not quite so bad as in 1880, I think, but it was very bad even in 1881.

5561. I think you have a few notes of your observations during that hot time in July 1881?—Yes.

5562. (*Chairman.*) From October until the following July you did not observe anything offensive in the condition of the river?—Not so bad as it was in the summer. I think I made notes from time to time, but there were not very many notes made. The water was cool, and of course the state of the river is very different in winter from what it is in summer.

5563. (*Mr. Lumley Smith.*) In the autumn is there more or less fresh water coming down?—I think there is more as a rule then.

5564. And it is cool?—Yes.

5565. At any rate the bad time comes in very hot weather?—Yes, in hot, sultry weather.

5566. Will you read the entry that you have for the 14th day of July 1881?—" River water heavily
" charged with sewage and smelling badly."

5567. What entry have you on the 15th of July?—
" River water smelling badly and much discoloured
" with sewage."

5568. What is your entry on the 18th of July?—
" River water this day offensive and heavily charged
" with sewage."

5569. What is your entry on the 19th of July?—
" River water this day in filthy condition, especially
" between Blackwall and Purfleet."

5570. What is your entry on the 20th of July?—
" River water in very bad state."

5571. What is your entry on the 21st of July?—
" River water throughout the whole district this day
" in a filthy condition from sewage."

5572. What is your entry on the 23rd of July?—
" River water in an exceedingly bad state, even at
" high water."

5573. What is your entry on the 25th of July?—
" River water in filthy condition at half ebb, and
" smell most offensive."

5574. What is your entry on the 26th of July?—
" River water very filthy at half ebb, heavily charged
" with sewage."

5575. (*Sir John Coode.*) In what part of the river?—When I have not distinctly stated the part of the river, I mean that it is generally so throughout the district.

5576. (*Mr. Lumley Smith.*) What is your entry on the 27th of July?—" River water heavily charged
" with sewage."

5577. What is your entry on the 28th of July?—
" River water very offensive this day, especially off
" Erith and Woolwich."

5578. What is your entry on the 30th of July?—
" River water this day rather better, and the smell
" not so offensive."

5579. Your next entry is on the 2nd of August; what is it?—" River water very filthy at half tide, and
" the odour very offensive."

5580. What is your entry on the 5th of August?—
" River water this day very offensive and full of
" sewage."

5581. What is your entry on the 6th of August?—
" River water full of sewage, and the odour very
" offensive."

5582. What is your entry on the 8th of August?—
" River water this day rather cleaner, and not smell-
" ing so badly."

5583. What is your entry on the 9th of August?—
" River water same as yesterday."

5584. What is your entry on the 10th of August?—
" River water on the ebb in a filthy state, especially
" in Erith and Halfway Reaches."

5585. What is your entry on the 12th of August?—
" River water heavily charged with sewage, and smell-
" ing badly at half flood."

5586. What is your entry on the 19th of August?—" At $2\frac{3}{4}$ hours before high water this evening sewage
" from the northern outfall in Barking Reach was ob-
" served to be flowing into the river, a sample of
" which was obtained in front of the works by George
" Lamerton and Thomas Long, watermen of the Con-
" servancy; time, 6.40 p.m."

5587. (*Sir John Coode.*) At what time was it high water on that day?—That was at $2\frac{3}{4}$ hours before high water.

5588. (*Mr. Lumley Smith.*) Have you the time of high water there?—High water would be about 25 minutes past 9 on that day.

5589. I think your entry on the 20th of August is, that two men were employed during the night?—Yes. " Two hands employed during the night tide to
" take samples of river water at the metropolitan out-
" fall in Halfway Reach."

5590. What is your entry on the 21st of August?—" Two hands at northern outfall, Barking Reach, at

" half-flood night tide. Reported sewage coming " through the sluices at 9.30 p.m. High water at " 11.35."

5591. Could you give us the names of those two men?—George Lamerton and Thomas Long. They are both here.

5592. What is your entry on the 23rd of August?—" Two hands in harbour boat attending at northern outfall during the night flood tide; observed sewage " coming through the sluices at 11 p.m. Sample " taken."

5593. Who were the men?—George Lamerton and Thomas Long.

5594. What is your entry on the 24th of August?—" Two hands in harbour boat at the northern out- " fall during the night flood tide."

5595. On the 25th there is a similar entry as to the southern outfall?—Yes.

5596. Then I believe you went away on leave through September?—I went away on leave in September.

5597. I think you have an entry in October of that year, after you came back from your vacation?—I have, " Sewage from northern outfall very offensive " this tide." That is on the 19th of October.

5598. You have a few, I think, in 1882; this year?—Yes.

5599. Have you an entry on the 17th of March 1882?—Yes. " At the last quarter ebb to-day the " river in Halfway Reach and off Erith was in a very " foul state and smelling badly."

5600. On the 30th of June what entry have you?—" At 9 o'clock this morning the river water off " Charlton was very offensive, and smelt strongly of " sewage at two hours flood."

5601. Charlton is above Barking, is it not?—Yes, it is above Woolwich.

5602. What is your entry on the 10th of August?—" River water to-day at last quarter ebb in Halfway " Reach was very turbid and full of air bubbles, " giving off an offensive odour."

5603. What is your entry on the 28th of August?—" River water in Halfway Reach and off Erith very " much discoloured and smelling badly."

5604. Then I think you went away again in September?—I did.

5605. Then you have an entry on the 26th of October; what is it?—" Water in Barking Reach to- " day heavily charged with sewage and smelling " badly."

5606. Did you make a point of making entries about the river during the rest of the year as well as in the two Julys and Augusts, when you seem to have made almost daily observations?—No, I confine myself more to the summer months.

5607. What was your practice as to making entries about the river, and when did you begin to make those entries?—I think I commenced in 1878, the year after I first came to the Thames.

5608. As those were the two bad months, you have put them down very carefully?—Yes, especially in 1880 and 1881.

5609. Has not the water been so bad in 1882 as it was in previous years?—No, it has been exceptionally clear, as it is now.

5610. Can you account for that in any way?—The way in which I account for it is, that we have had very strong winds from the west and south-west, and a great deal of rain.

5611. You have told the Commission that you think this foul condition of the river is caused by the sewage; are you able to tell them from what particular parts or places the sewage comes?—The sewage comes through the northern outfall just above Barking Creek, and it comes through the southern outfall just below Crossness Point.

5612. Is it sewage that has come down the river from above bridge, or is it sewage that has come from below from the outfalls?—My opinion is that it is the sewage that comes from the outfalls.

5613. I believe you did make some observations in the year 1878 on the depth of the mud found in different places, did you not?

(*Mr. Bidder.*) I would remind my learned friend that this witness gave these observations in evidence upon the last inquiry.

(*Mr. Lumley Smith.*) I propose to hand the statement in, but not to take it through the witness. This statement gives the depth of the mud found at various places on the 18th of December 1878.

(*Mr. Bidder.*) In the first place, it takes a considerable time, and if it is material, it would be my business to cross-examine upon it; and besides, it is simply going back to an exhaustive inquiry which has already been held, and upon which a decision has been given.

(*Chairman.*) Not by us.

(*Mr. Bidder.*) I do not mean to say that the Commission are stopped from going into it; but I put it to the Commission and to my learned friend whether, under the circumstances, it is worth while to re-open an inquiry which has been thoroughly threshed out.

5614. (*Chairman, to the witness.*) What are these observations?—These are observations that were taken in the year 1878.

5615. By yourself?—By myself. (*The witness handed in the following statement.*)

DEPTH of MUD found in the following PLACES, 18th DECEMBER 1878.

WOOLWICH REACH.

Just outside the line of mooring buoys off the Dockyard:—

Abreast of Lower Graving Dock, 5 ft.
Ditto of Upper Graving Dock, 8 ft.
Ditto of No. 2 Crane, 9 ft.
Ditto of Clock House, 9 ft.
Ditto of Landing Stage, 7 ft.
Ditto of Lower Building Shed, 8 ft.
Ditto of Charlton Pier, 5 ft.
Ditto of Siemen's Telegraph Works, 8 ft.

BARKING REACH (Essex shore).

Just above Farmer's Teeth, 150 ft. from low water, 12 ft.

400 feet from low water, and off the pitch of Crossness Point, 12 ft.

500 feet from low water off the pitch of Crossness Point, 10 ft.

120 feet from low water abreast of 2nd fence below magazine, 8 ft.

120 feet from low water, midway between upper and lower fences, 10 ft.

120 feet from low water, abreast of upper fence, 11 ft.

120 feet from low water, between magazine and upper fence, 10 ft.

120 feet from low water and abreast of magazine, 7 ft.

HALFWAY REACH.

Mid-Channel, 18th December 1878.

Tide gauge in with No. 2 chimney, 10 ft.

Fountain, midway between 2 chimneys in grounds, 8 ft.

Abreast of main shaft, 9 ft.

Mid-Channel, 20th December 1878.

Off Powder Creek, 7 ft.

Abreast of mud shoot, 9 ft.

One quarter off, 20th December 1878.

Abreast of main shaft, 12 ft.

ERITH REACH.

At Erith Pier, 20th December 1878, 5 ft.

120 feet from end of Causeway, 20th December 1878, 11 ft.

*Capt. J. Fitzgerald, R.N.*

5 Dec. 1882.

120 feet from low-water mark, 20th December 1878:—

Lower Ballast Wharf, 15 ft.
Upper Ballast Wharf, 10 ft.
Gas Wharf, 12 ft.

NOTE.—20th November 1882. Steamship "Fatfield" was in collision, owing to which she was ran ashore on the Essex side of Barking Reach, just above the Farmer's Teeth. The vessel ebbed dry at low water; but embedded herself in mud nearly 12 feet.

5616. (*Sir John Coode.*) What was the general result of these observations; was it that there was any addition to the accumulations or not?—I think it went to prove that the mud was increasing in the river.

5617. That is the general conclusion that you drew from these observations?—That is the conclusion that I drew.

5618. (*Mr. Lumley Smith.*) Are you able to tell us of what this mud was composed?—My opinion at the time was that it was composed mostly of sewage.

(*Mr. Bidder.*) I object to that, unless he has made an analysis.

5619. (*Mr. Lumley Smith, to the witness.*) You made no analysis of the mud, I understand?—No, not personally.

5620. Are you familiar with Thames mud?—I am.

5621. Was this mud that you found here of the same character as Thames mud, or did it differ in any important particular?—It varied in character apparently. In some places it was black, stinking mud, and in other places it was not quite so bad.

5622. I see that your list which has been handed in does not state the character of the mud at different places?—No. Samples were taken at these places from time to time, and they were analysed by those who were able to do it.

5623. Of course the important ingredient in this inquiry is whether it was sewage or what it was. One more question on the subject of depths. Quite lately, I believe, there has been a steamship, the "Fatfield," in collision?—Yes, I think I have a note of it in my journal.

5624. On the 20th of November 1882, a fortnight ago, what is your entry?—"The 'Fatfield' was in col-
" lision in Halfway Reach, and was compelled to run
" ashore to avoid sinking, and she embedded herself
" in 12 feet of mud in Horseshoe bight."

5625. Did you see that yourself?—I saw it myself.

5626. What was the nature of the mud there?—It looked like black, stinking sewage mud, the whole of it.

(*Dr. Stevenson.*) Where is Horseshoe Point?

(*Mr. Bidder.*) It is just opposite Leather Bottle Point.

Cross-examined by Mr. BIDDER.

5627. I believe that the depths of mud which you have now handed in to the Commission are the same observations that you took for the purpose of the inquiry which was held in the year 1879?—Quite so.

5628. In which your masters, the Conservators, charged the Metropolitan Board with having caused large mud banks in that part of the river?—Yes.

5629. I should just like to identify them. One was a large mud bank opposite Crossness outfall, from there up to Leather Bottle Point on the south side of the river?—Yes.

5630. And another was a mud bank in that place which you have just mentioned, Horseshoe bight, at Dagenham?—Yes.

5631. And another was at Margaretness, a little higher up the river?—Yes.

5632. And you not only took observations but you gave evidence before the arbitrators in that case, Sir Charles Hartley, Sir Frederick Bramwell, and Captain Galton?—Yes.

5633. And all these figures were before them?—Yes.

5634. As you say, you did not analyse the mud, but the mud was analysed by other people who gave the result of their observations?—That was so.

5635. Perhaps it is within your knowledge that the result of these proceedings was that the arbitrators decided———

(*Chairman.*) Surely the arbitrators' decision was in writing.

5636. (*Mr. Bidder, to the witness.*) I merely want to get the fact from you; that what you are putting in now is nothing more than what you gave in evidence on the former arbitration as regards that part of the case?—That is so.

5637. First as regards your opinion as to what you call sewage and the offensive matter which you observed in the river, principally I gather between Charlton and Woolwich, when you express an opinion as to where it comes from, may I take it that that is a mere question of inference, and that it is not from tracing it to one place or the other. Of course we all know that you or anybody else can see large volumes of sewage pouring into the river at Barking and Crossness. May I assume that you infer where it comes from?—I take it for granted, in consequence of what I see.

5638. I understand that you have been, since the autumn of 1877, stationed in that part of the river?—Yes.

5639. And I think it was in the winter of 1879 that you gave evidence on the last inquiry?—I think it was.

5640. And you expressed at that time a strong opinion adverse to the effect of the metropolitan sewage, not only as regards the fact of the mud banks, but as regards the offensiveness?—I almost forget whether I expressed any opinion with regard to the sewage. I think the inquiry at that time had reference to the banks of mud.

5641. But it had reference to the cause of them?—Yes.

5642. And you expressed an opinion as to the offensive results produced by the sewage?—Yes.

5643. If I recollect rightly, you were cross-examined, and you adhered to your opinion and took a very strong view upon the subject—I do not say unnecessarily strong. Am I right in supposing that until after that time there are practically, with one or two exceptions, no entries in your diaries of any particularly offensive condition of the water?—So far as I remember, I commenced to make entries in my journal shortly after I came into the river, in 1877. I think I commenced to make entries before 1878.

5644. One part of your diary you have sealed up, for some reason or other, so that I have not looked at that?—Those were my predecessor's observations, and I sealed them up because of course I could not be responsible for anything he said.

5645. So far as I have seen, there is no entry of the water being in a bad condition before 1879. Of course I do not pretend to say that I have read the entries exhaustively?—I think, so far as I know, I put them all down on this paper, but I will not be quite sure. Perhaps you will allow me to look at it. My observations were more particularly directed to the subject in the years 1880 and 1881, because the river was then at its worst.

5646. Let us get at the facts first, and then you can make any explanation you please afterwards. What entries have you before the year 1880?—The following are extracts from my journal as harbour master of the central district for the years 1878 to 1882. " On the 20th of December 1878, tides very sluggish,
" owing to which the water in Halfway Reach and
" also in Barking Reach was found to be in a very foul
" state, and heavily charged with sewage."

5647. What is your next entry?—The next is on the 2nd January 1879. "Tide sluggish, water in "Halfway Reach heavily charged with sewage matter;" and on the 16th of July, "Watchman on board the "steamer 'Conservator' at Charlton reports a strong "smell of sewage round the vessel on the flood tide." On the 19th of July the entry is, "a strong smell of "sewage round the vessel at her moorings, and the "water presenting all the appearances of being charged "with sewage matter."

5648. Is that also the report of the watchman?—No, it is my own observation.

5649. What vessel is that?—On board my own vessel at her moorings at Charlton. That is all I have in the year 1879.

5650. Those three observations are all that you have until the 24th of June 1880?—Yes.

5651. I think you have also some observations in your diary, which you have not extracted, of an opposite character as to the remarkable purity of the river at certain times, have you not?—I am very sorry to say that it is not often in such a state as to justify such a statement.

5652. (*Chairman.*) Have you any such entries?—I think I have one, and it must be three years ago since I made such an entry; and then it was in Long Reach.

5653. (*Mr. Bidder.*) You did not think it worth while to extract it?—I did not think it worth while to extract it, because it is the only observation of that character that I ever made. It is in my journal, but I could not put my finger upon it at this moment.

5654. Will you turn to the 17th of March 1879?—I think that bears out what I said. "Ebb tide very "sluggish, and water in the river very clear off "Greenhithe." I think that was the observation that I made about three years ago.

5655. Will you try the 1st of April?—"To-day the "river water was remarkably clear throughout the "whole district, especially between Erith and Green-"hithe. Tide sluggish." You see I marked it in order to give it if it was required.

5656. Then the next entry you tell us is on the 24th of June, and then we have got all the others down upon the notes. I am not going through them in detail; but when you speak of the water being "charged with sewage" (or similar expressions), I want to know exactly what it is that you intend to convey; was it discolouration, or muddiness, or what?—The answer to that is, that I considered that the water was full of sewage from its containing a lot of suspended matter which was really like sewage. It was my opinion that it was sewage.

5657. You inferred that it was full of sewage from its containing suspended matter?—Yes.

5658. Then, again, you have spoken several times of the smell of the water; I want to get a distinct understanding about the foundation for that. I will take, for instance, one of your last entries. You said that on the 10th of August 1882, at the last quarter of the ebb in Halfway Reach, the water was turbid and full of air bubbles, all across the river, and smelling; how did you make that observation?—I saw it with my own eyes, and I smelt it.

5659. You could not see a smell?—No; but I saw the bubbles with my eyes, and my nose told me that there was a very unpleasant smell.

5660. Were you in a vessel on the river?—I was in my own boat.

5661. In the Conservators' launch, I suppose?—In the Conservators' launch.

5662. Going up and down in the district?—Going up and down in the district.

5663. Perhaps you will tell me also how you happened in the summer of 1881 to be watching the outfall at night?—The river was in a very filthy state, and I wanted to ascertain the reason; and I was under the impression that the sluices must have been open on the flood tide to produce such a state of things. Accordingly I sent two of my men (who are both here) during the night tides to find out if such was the case.

5664. (*Chairman.*) Did you go yourself?—Not during the night tides. I have seen the sluices open during the day tides on the flood; but on this occasion I sent two men.

5665. (*Mr. Bidder.*) One other thing that I want explained is this: when you say "water clear on the "surface, and filthy and stinking underneath," how is that observation made?—If you were to go in the wake of a steamer going down the river on these occasions you would see that the lower part was stirred up by her screw, and you would find that that which was stirred up was in a stinking, filthy condition, whereas that which was upon the surface was comparatively clean.

5666. Then that is from observations in the wake of steamers, and other observations of that character?—Just so.

5667. Will you tell me where that observation was made?—It was made in almost every part of my district, excepting in Long Reach; I do not think I could apply such an observation to Long Reach.

5668. It is put upon a particular day. Let me see your diary for that day, the 21st of July 1880?—"River water this day fairly clean on surface, but "filthy and stinking underneath."

5669. That is the date. Will you let me see your diary (*the diary was handed to the learned counsel*); can you say from your diary what part of the river that particularly applied. I see you were in Jenningtree Reach?—Yes; at that time of the year I should think it applied to every part of the river within my district except Long Reach.

5670. I see by your diary that you were off Jenningtree Point examining sand barges, or doing something of that kind?—Yes.

5671. You cannot tell me from memory at what particular part of the river it was, but you express a general opinion that it would apply generally?—Yes; so far as I recollect it would apply to every part of my district above Long Reach.

5672. On the 22nd of that same month, I think you speak not only of the water being better, but of the sewage "apparently working up;" will you give me an explanation of that phrase?—What I meant by that was that as the season advanced, and as the sewage became worse in the river, so it extended itself upwards. First it was not so bad above Woolwich. It then was not so bad above Charlton. Then it worked its way to Blackwall. Lastly, it got as far as Greenwich.

5673. But that rather puzzles me, because that day's entry speaks of its being bad between Charlton and Erith?—On the 22nd this is the entry, "River in "filthy condition between Charlton and Erith, and "sewage apparently working its way higher up the "river."

5674. That is what puzzles me, because you say that that means going up as the season advances. If I took your answer down rightly, the week before that you had recorded it as very bad in Bugsby and Blackwall Reach, which is higher up still?—Yes, but I do not think I made use of the words "filthy condition" in Bugsby and Blackwall Reach.

5675. I have not your scale of gradations of terms of abuse, but you used some such phrase. Will you look at your entry on the 15th?—On the 15th the entry is "River water greatly discoloured with sewage "in Bugsby and Blackwall Reach, and smelling very "badly," whereas on this day it is "filthy."

5676. Have you noticed the river at the present time?—I have; I am on the river almost every day.

5677. What is its condition now?—Very much better; better than I have seen it for three years.

5678. Is it charged with sewage?—I have no doubt there is a great deal of sewage in the river; in fact, I am sure there is.

5679. That we all know, seeing that it is poured in twice a day from two great outfalls?—But appa-

*Capt. J. Fitzgerald, R.N.*

5 Dec. 1882.

rently the river is cleaner or sweeter than it has been for three years.

5680. Is there, to your observation, anything offensive about it at the present time?—Speaking generally, no.

5681. You have observed nothing offensive in this present year, excepting upon those days which you have recorded?—I will not say that. Upon those days when I recorded it, it was very bad; and there were other days when it was bad too, but when I did not consider it necessary to make any observation in my journal.

5682. Did you ever examine the black patches which you spoke of upon one occasion, and which you say were the size of this room, or larger, in order to see what they were composed of?—I have steamed through them; I have gone through them in my boat hundreds of times.

5683. Are they a novelty upon the river; have you known the river in olden times?—No, I cannot say that I have known the river very long. I knew it years ago, before the metropolitan sewers were constructed, but I did not know so much about it then as I do now.

5684. You knew it generally?—Yes; I was occasionally upon it in river boats.

5685. I gather that you have never analysed or examined the sewage?—Not personally.

5686. Have you ever taken any observations of the temperature of the water?—I have.

5687. Have you got them recorded?—No, I cannot say that I have ever recorded them; but I have taken observations for my own private information.

5688. For instance, on those occasions in the summer time, have you recorded them?—No, I have not recorded them, but I have taken observations of the temperature of the sewage and of the clear water, when it was clear. I have found a very great differ, ence between the temperature of the water when it was heavily charged with sewage, and its temperature when it was apparently clean, as much as eight or nine degrees.

5689. Sewage has a warming effect; but as a matter of fact can you give me from memory what temperatures you have observed?—I cannot; they vary very much.

Re-examined by Mr. Lumley Smith.

5690. I think you told us that you employed these men in August 1881 to take samples at the outfalls, and to watch the outfalls?—Yes.

5691. What was done with the samples?—The samples were submitted to the Conservators, and I believe they gave them to their analytical chemist.

5692. The men brought them to you?—The men brought them to me, and I submitted them to the head office at No. 41, Trinity Square, where they were, I believe, transferred to the analyst.

5693. (*Chairman.*) You gave them to somebody?—I gave them to the Conservators.

5694. (*Mr. Lumley Smith.*) I see that on two occasions the men reported sewage coming through; would that be by word of mouth, in the morning?—They brought their reports to me in the morning; I believe they made notes at the time.

5695. (*Chairman.*) The question put to you was, did they deliver their reports to you by word of mouth or in writing?—They reported to me verbally.

5696. (*Mr. Lumley Smith.*) Do you remember whether the year 1879 was a warm or a cold year?—I cannot say that I remember.

Examined by the Commission.

5697. (*Chairman.*) You say that you went with your boat through these black patches?—Yes.

5698. You saw those patches; did you smell them?—Yes.

5699. From what your eyes told you, and your nose told you, what inference did you draw as to what those patches were?—That they were patches of sewage.

5700. (*Sir John Coode.*) You handed in a statement from which, if I rightly understood you, you said that you drew the general conclusion that there had been an accumulation of mud; was that so?—That is when these observations were taken.

5701. But this statement goes to December 1878, and to December 1878 alone. I do not see how you can draw from a statement confined to a single month the conclusion that there had been an accumulation. Probably there is some further statement, which is missing from this one?

(*Mr. Bidder.*) It is right to say in justification of the witness that we compared these soundings with old Admiralty soundings.

(*Witness.*) I do not think I have made entries of any previous observations, but being on the river every day, as I am, I go probing about here and looking yonder in all parts through my district, and I make observations in my mind as to the state and condition of the district generally; but I have not made any entries in my journal of the depth of the mud, excepting these.

(*Sir John Coode.*) This statement is handed in, and you said in reply to a question that you drew the general conclusion from it that there had been an accumulation of mud. Taking this statement *per se*, it is impossible to draw any conclusion one way or the other, because it refers only to a single month; I should imagine that there are some further observations upon which you have instituted your comparison.

(*Mr. Bidder.*) The witness omitted to say that he drew the conclusion comparing these soundings with the previous condition of the river.

5702. (*Chairman, to the witness.*) I understand you to say that you have been about the river since you took these observations?—I have been about the river ever since I took them. These observations were made in the year 1878, and I have been on the river ever since.

5703. You said just now, in answer to Sir John Coode, that you had drawn the inference that there had been an accumulation; when did you draw that inference?—When these observations were made.

5704. You made certain observations in December 1878?—Yes.

5705. Now you say that you infer that there has been an accumulation?—Yes.

5706. Was the inference that the accumulation had been made in December 1878?—No, not confined to that month.

5707. (*Mr. Abernethy.*) I understand that these observations were made with a view of comparing the state of the river at that time with the previous charts?—Just so.

(*Sir John Coode.*) With that explanation we understand what it means; but as this statement is put before us, accompanied by an answer by Captain Fitzgerald to the effect that he drew from this the conclusion that there had been an accumulation, I say that this statement does not show that, one way or the other; but an explanation has now been given which clears it up.

(*Mr. Bidder.*) There is no dispute as to the fact.

(*Witness.*) I have a thorough knowledge of the charts and of the recent surveys.

5708. (*Sir John Coode.*) Did you institute a comparison between 1878 and the present date, or a subsequent date, or between 1878, and some previous date?—Between 1878 and some previous date.

5709. What is that previous date?—It extended over a great many years. The surveys of the river have taken place from time to time, and I compared the depths of the water and the mud which I obtained with those surveys which were obtained previously, and recorded in our office; and I could see the difference, and it was from that that I drew my conclusion.

5710. (*Chairman.*) You have made no examination since?—I am constantly making examinations of the river in various parts, making soundings in various parts, and taking the depth of the mud, and so on.

5711. Can you give us any opinion as to whether there has been any increase in the accumulation since December 1878, down to the present time?—I think there is an increase always going on; I think it cannot be otherwise.

5712. (*Sir John Coode.*) Do you attribute that increase wholly and solely to the sewage?—I will not say wholly and solely, but I think the sewage contributes a very great share.

*Capt. J. Fitzgerald, R.N.*

5 Dec. 1882.

5713. (*Dr. de Chaumont.*) Have you observed an increase?—I have observed increases of mud on the foreshores, and I know that in certain parts of the river there is less water than there used to be, and I take it for granted, as there is such an enormous quantity of solid matter coming down the river, that it must help to form these banks and make the water shallower.

(*Mr. Bidder.*) I hope it will be remembered that as to the fact of accumulations in this part of the river there is no dispute at all.

The witness withdrew.

CAPTAIN CHARLES HENRY JAMES called in; examined by Mr. LUMLEY SMITH.

*Capt. C. H. James.*

5714. I believe you are the harbour master of the Thames Conservancy at Greenwich?—I am.

5715. I believe you have known the river all your life, have you not?—I have.

5716. And how long is that?—That is 67 years. I am 69 years old.

5717. I will ask you one or two questions about the early condition of the river. You went to sea in 1828, did you not?—Yes, in the latter part of 1828.

5718. You used, then, to drink the Thames water, I believe?—Yes.

5719. And you took it to sea with you?—Yes.

5720. What part of the river did you take it from then?—The first duty I had on board a ship was in the latter part of 1828, when I was put to see the men fill the water from alongside the hulk outside the East India Dock.

5721. It was taken from there and taken to sea in casks?—Yes.

5722. How long have you been harbour master at various parts of the river?—Since February 1840.

5723. In that year were you stationed at Gravesend?—I was.

5724. And your district extended, I think, up to the lower part of Woolwich?—It did.

5725. And were you constantly on the river?—I was constantly on the river between Gravesend and Woolwich for 11 years.

5726. Are you now in the service of the Thames Conservancy?—Yes.

5727. You are now harbour master at Greenwich?—Yes.

5728. What is Captain Fitzgerald?—Harbour master on the central station from Greenwich down to Greenhithe.

5729. (*Mr. Bidder.*) You are in the upper part of the river?—Yes, in the pools.

5730. (*Mr. Lumley Smith.*) From 1840, for 11 years, your district was from Gravesend to the lower part of Woolwich?—It was.

5731. During that time was the water good in that district?—Perfectly good and sweet.

5732. Was it drunk at any time of the tide?—You could drink it as far as Halfway Reach. You could have drunk it, I do not say we ever did; but it was perfectly drinkable at low water.

5733. That would be when fresh water was running down, I suppose?—Yes.

5734. In the year 1850 you came to Limehouse district, did you not?—In 1850 or 1851, I will not be quite certain which.

5735. Your district then extended from Greenwich up to London Bridge?—From Limehouse to London Bridge.

5736. At that time was the Thames water drunk?—Yes, it was.

5737. Where was it drunk?—It was drunk at Limehouse. A good many people used to drink it.

5738. There were pumps there, were there not?—Yes. Very shortly afterwards it ceased to be drunk; but it was drunk in 1851 when I was there.

5739. Do you remember where the whitebait used to be caught?—It used to be caught at the East India Dock entrance at Blackwall.

5740. Now, I believe, there is none to be met with there?—There is none to be met with in the river at all; they are obliged to go into the other river for it.

5741. You remember, do you not, the outfalls being opened at Barking and Crossness?—I do.

5742. Do you remember in what year that was in?—1863, 1864, 1865, and 1866.

5743. Since that time has there been any change in the character of the water?—Yes, it has got very foul.

5744. What parts, in your judgment, have become foul?—From London Bridge downwards, the whole of the river; and that is proved, I think, by the eel-schuyts, the eel vessels that used to lie at Erith; they are now driven away to Hole Haven, and they cannot even lie in the river there.

5745. You are speaking there, I presume, chiefly from hearsay, are you not?—No, I am speaking from knowledge, that they are driven away from Erith. They were driven away from Erith, I think, in 1869. They went down to Greenhithe then, and they were driven away from there in 1870. They went to Gravesend and lay there two years, I think; and now they are driven away down to Hole Haven.

5746. I believe from time to time when the water was very bad you have reported, have you not?—Yes.

5747. And you have made entries in your journal?—Yes.

5748. Did you do that generally with regard to the river, or only when it was very bad or very good?—Only when it was very bad.

5749. Have you your journals here?—They are here (*producing them*).

5750. In 1880 have you an entry on the 29th of July?—I cannot speak before that for the month of July, for I was absent.

5751. (*Mr. Bidder.*) Is this the first entry in any year?—I think it is. I was not ordered to do it before then.

5752. (*Mr. Lumley Smith.*) How came you to make these entries in the year 1880?—I was de ired by Captain Burstall, the secretary of the Conservancy, to make an entry of the state of the water.

5753. And in consequence of that you did it?—Yes.

5754. What is your entry on the 29th of July?—"Water in the river very black, and offensive to the "smell."

5755. What is your entry on the 30th of July?—"Water in the river very black and offensive."

5756. (*Mr. Bidder.*) Can you fix the place?—From Greenwich to London Bridge.

*Capt. C. H. James,*

5 Dec. 1882.

5757. (*Mr. Lumley Smith.*) How would these observations be taken? Did you go out to a particular spot, or were they taken as you were rowing up in the course of your duty?—In the course of my duty; as I was going up from Greenwich to London Bridge and back again.

5758. This is the result of your observation in that trip?—Yes.

5759. You are not able to specify any particular reach or anything of that sort?—The whole of the river from London Bridge to Greenwich.

5760. What is your entry on the 31st of July?—"The water very black and offensive in the creek as "well as in the river." That is in Deptford Creek. "To Deptford by train and visited and inspected the "creek;" that was Deptford Creek.

5761. What is your entry on the 1st of August?—"Water in the river very foul and offensive."

5762. What is your entry on the 2nd of August?—"Water in the river very black and offensive."

5763. What entry have you on the 3rd of August?—"Water in the river very much discoloured and "offensive."

5764. What entry have you on the 4th of August?—"Water in the river very foul and offensive."

5765. What is your entry on the 5th of August?—"Water very foul and offensive."

5766. What entry have you on the 6th of August?—"Water in river very foul and offensive."

5767. What is your entry on the 7th of August?—"Water very foul and offensive."

5768. What is your entry on the 8th of August?—"Water in the river very foul and offensive." That was confined to the forenoon.

5769. What is your entry on the 9th of August?—"The water in the river very foul and offensive."

5770. What is your entry on the 10th of August?—"Water in the river very foul and offensive."

5771. What entry have you on the 11th of August?—"Water in the river very foul and offensive."

5772. What is your entry on the 12th of August?—"Water in the river very foul and offensive."

5773. (*Mr. Bidder.*) There is not much originality about your entries. Captain Fitzgerald had a much more extensive vocabulary?—Very likely, but I do not see how it could be altered. It was very foul and offensive.

5774. (*Mr. Lumley Smith.*) The 13th and 14th are very much the same, are they not?—I do not think I have any entry on the 13th.

5775. What is your entry on the 15th of August?—"Water in the river very foul and offensive." I do not see what else I could say.

5776. What entry have you on the 16th of August?—"Water in river of a rather improved character."

5777. What is your entry on the 17th of August?—"Water in the river very foul and offensive."

5778. I think to the end of the month it is very much the same, is it not?—"River and creek very "foul and offensive" on the 20th.

5779. What entry have you on the 1st of September?—"Water in the river foul and offensive."

5780. Do you jump then to the 13th of September; have you any entries on the 2nd, and so on?—"Water foul" on the 2nd.

5781. I think it improves on the 14th of September, does it not; what is your entry on the 14th?—I do not think I have any. On the 15th I have this entry, "Water not so foul and offensive as it has been."

5782. Have you an entry on the 21st of September?—"Water very foul."

5783. Then I think you have no more entries that year. On July 5th, 1881, did the water get very bad again?—The entry on that date is this: "Water very "offensive at high water, and continued so until quite "half ebb."

5784. That is at high water between Greenwich and London Bridge?—Yes.

5785. What is your entry on the 6th of July?—"Water in the river less offensive."

5786. Then I think you have no entry until the 14th of July?—"The water in the river very dark and "discoloured, and very offensive towards high water "as far as Limehouse."

5787. When you say as far as Limehouse, would that be from Greenwich to Limehouse?—From Greenwich to Limehouse.

5788. What is your entry on the 15th of July?—"Water very foul and offensive at high water, until "half ebb or 8 p.m."

5789. The entries on the 16th and 17th, I think, are very much the same, are they not?—The entry on the 16th is, "Water very foul and offensive," and the entry on the 17th is "Water foul and offensive at high "water."

5790. What is your entry on the 18th of July?—"Water in the river very foul and offensive towards "high water or 6 a.m."

5791. What is your entry on the 19th of July?—"Water foul and offensive in the first and latter "parts."

5792. What does that mean?—That means that at 9 o'clock in the morning it was very foul and offensive, and the "latter parts" means before 8 o'clock at night.

5793. It means parts of the day, and not parts of your district?—Quite so.

5794. What entry have you on the 20th of July?—"Water foul and offensive at high water, 8 a.m. until "half ebb."

5795. What is your entry on the 21st of July?—"Water in the river very foul and discoloured towards "high water and until a quarter ebb, and very offen-"sive. High water at 9.50 a.m. The same at "night."

5796. On the 22nd of July I think it took a turn for the better?—"Water not so offensive as for days "past."

5797. What is your entry on the 23rd of July?—"Water in the river foul and very offensive near high "water and at the half ebb. High water at noon."

5798. I think there is no entry on the 24th of July. What is your entry on the 25th?—"Water less foul "and offensive."

5799. Then from the 26th to the 30th of July the entries are much the same, I think. Then on the 1st and 2nd of August what entries have you?—"Water "in the river very foul and offensive" on the 1st, and then "Water in river foul and offensive" on the 2nd.

5800. On the 3rd of August what entry have you?—"The water in the river not so foul or offensive as "it has been, but still offensive."

5801. Then you went away on leave?—I went away on the 4th of August.

5802. You live at Greenwich, do you not?—Yes.

5803. Are you near the river?—Close to it.

5804. Do you find anything disagreeable from the river?—Yes, I do.

5805. What do you find?—A very disagreeable smell. I always sleep with my window open as long as I can; that is, from about May till October; but I have frequently had to get up and shut it.

5806. Why?—The smell was so disagreeable.

5807. That you find you are obliged to do for your own comfort?—Yes; and I have frequently been made quite ill with it going up and coming down, so that I have not been able to eat my dinner when I have got home.

Cross-examined by Mr. Bidder.

5808. Your journey up and down is between Greenwich and London Bridge, is it not?—It is in general, but I have done the duty on the central station several times.

5809. But generally your journey is from Greenwich to London Bridge and back?—Yes, it is.

5810. I believe it is the fact that a very large number of people in the summer time take that water

journey for pleasure?—I daresay they do. It is more than I should do.

5811. Naturally, as it is your business, you would hardly go to the same place for your recreation. You have been on the river, and, as you say, acquainted with the river for a long time. You spoke of the time when the water used to be drinkable; is it not the fact that when Thames water in the olden days was taken on board ships and put into casks it always fermented or putrefied in the first instance?—Yes, it always did.

5812. They kept the bungs out of the casks to let the gases escape, did they not?—Yes; if you did not it would set on fire if you put a light to it.

5813. Do you say that the condition of the river in your district from Greenwich to London Bridge is worse than it used to be?—It is worse than it used to be before the year 1854.

5814. Then, if any gentleman has told the Commissioners that it is better in that part of the river than it used to be, he is saying what is contrary to the fact?—The general tone of the water is much better; but in the hot weather, or when there is very little water coming down the river, then it is very bad.

5815. Then your observation is, that generally the river is in a much better condition than it was in before the outfalls were made?—I do not say that; I say the water is sweeter.

5816. Sweeter than it was before the outfalls were opened?—Yes, all up here; that is to say, from London to Limehouse.

5817. Mr. Edmonds, a witness who was called before the Commission, says that the upper reaches of the river, that is to say, from London Bridge to Limehouse, have become purer, and that the lower reaches of the river have become fouler year by year?—That is just what I say.

5818. You agree with that so far?—I do. I mean by the upper reaches, from Limehouse to London Bridge.

5819. With regard to your journal observations, I think you were one of the witnesses that I had the pleasure of examining upon the last occasion, when you tried to father the mud banks on us?—I think the mud banks are caused by the sewage. I am certain of it. I said they would do so, and they do do so.

5820. You were one of the witnesses?—I was.

5821. And you were examined at about the same time as Captain Fitzgerald?—I do not know. I was examined.

5822. Then after that you had instructions, as I understand, from Captain Burstall to make notes of the condition of the river?—I do not know whether it was before or after; but I was ordered by Captain Burstall to do so, and I did so. It was no part of my duty to do so before. My duty is to regulate the ships, not to see about the water.

5823. I assume that you did it when you were told to do it; of course if any offensive matter comes to you from Barking and Crossness, it must pass through Captain Fitzgerald's district to get to you?—I suppose so.

5824. Can you explain to me how this happens; you begin your entries on the 29th of July?—I do not know when.

5825. Probably Captain Burstall had given you instructions about the 28th. Can you explain to me how it happens that at the time you begin your entries, the river being foul, I find Captain Fitzgerald recording that the river is getting better every day?—I do not care what Captain Fitzgerald says, I say my books are perfectly right.

5826. But you must have some respect for your colleague?—I have no respect for anybody who says anything contrary to what my books say.

5827. Is this a fair description of the state of the river on the 29th of July. "Water in the river rather "better to-day owing to the prevalence of strong "westerly winds"?—I do not know what Captain Fitzgerald says.

5828. Forget Captain Fitzgerald. I simply ask you whether this is a correct description of the river on that day, "Water in the river rather better to-day "owing to the prevalence of strong westerly winds"?

(*Chairman.*) He is speaking of a different part of the river. It is an excellent remark to make in a speech, but I do not know how it applies to the witness in the shape of a question.

5829. (*Mr. Bidder, to the witness.*) Is this a fair description of your part of the river?—If you can tell me the date I will tell you.

5830. The 29th of July 1880, the very day when you made your first record?—On the 29th of July I have this entry, "Strong west wind, with rain in "the middle part, lightning, thunder, and heavy rain."

5831. Is this a fair description of the river on that day, "Surface water fairly clean and free from smell"?—Certainly not in my district.

5832. Now I will go to the 30th of July. Is this a fair description of the river on that date, "Water in "river continues to improve, but the foreshore and "some of the landing-places clothed with sewage "mud"?—I cannot say what it had been before because I was absent until the 29th of July. I cannot say whether it had improved, because I cannot say what it had been before, and Captain Fitzgerald only says what it is in reference to what it had been.

5833. Now we have got to the 31st. Is this correct as describing the condition of the river on that day, "River water continues to improve"?—I do not know, "Water very black and offensive in the "creek as well as in the river." That is what I have got.

5834. You have no record of any improvement?—No.

5835. Now I will go to the 2nd of August. Is this a fair description of the condition of the river then, "River water moderately clear and free from "smell at high water"?—My entry is, "Water in "the river very black and offensive in the upper "district."

(*Chairman.*) I do not see the object of this cross-examination, because we have the two notes and we can compare the two.

(*Mr. Bidder.*) I do not think you have these passages, sir.

(*Sir John Coode.*) I understand that one witness is speaking with regard to one district and the other witness is speaking with regard to another district.

(*Chairman.*) If these entries have not been read, then Captain Fitzgerald ought to be called in again and cross-examined upon them.

(*Mr. Lumley Smith.*) I think you will find that they were all read. As I understand, that was the book from which Captain Fitzgerald was reading when he was examined.

(*Chairman.*) But as I understand Mr. Bidder he says that these passages were not read by Captain Fitzgerald.

(*Mr. Bidder.*) I think the course which you suggest is much more regular, and it will serve my purpose equally well. I have drawn the witness' attention to the passages and that is sufficient, I may be mistaken, but I think I am right in saying that those passages were not read; then I will pass from that.

(*Mr. Lumley Smith.*) If they are not in they shall be furnished to my learned friend, and he shall have an opportunity of seeing them.

(*Sir John Coode.*) If Mr. Bidder is not satisfied when he sees the print of the evidence perhaps he can re-call Captain Fitzgerald.

(*Mr. Bidder.*) I will just name the dates. August the 3rd, 4th, 5th, and 13th.

5836. (*To the witness.*) I take it that of late years your business has not taken you, as a rule, into the lower reaches of the river?—Not as a rule; I have been there several times.

5837. As regards the Dutch eel schuyts, your professional acquaintance with their place of anchorage must date from past years?—No, it does not; it dates till the time they left.

*Capt. C. H. James.*

5 Dec. 1882.

5838. You said that they anchored at Erith till 1869, I think. We have had some evidence here to show that they left Erith a good deal earlier; are you quite sure that you are right in your date?—Yes, I am quite sure that the last of the eel schuyts did not leave until 1869. Some of them may have left before, but not all.

5839. Then one other statement of yours rather startled me. You said that there are no whitebait in the river at all now, but that they have to go to "the other river"?—There are none at all.

5840. What is the river that they go to?—The Medway.

5841. Do you mean to say that no whitebait are caught in the Thames at all, practically?—No, not practically; or anything like what there used to be.

Examined by the Commission.

5842. (*Chairman.*) You say that the river between Greenwich and London Bridge is generally better than it used to be?—From the time that the sewers all came into the river, that was from 1851 or 1852. All the sewer outfalls, 170, or whatever the number was that used to pour into the river in 1864, were all taken down to this other place. It has improved the upper part of the river, except in very hot weather and except in very dry weather; and then the upper part of the river is just as bad as ever, or worse.

5843. You spoke of whitebait being formerly caught at Blackwall; did not that cease long before the outfalls were opened?—That ceased as early as 1851, and then they went down to Long Reach for them, and they have been driven away altogether now; they do not get them at all.

5844. (*Sir John Coode.*) You spoke of the river being generally foul and offensive between Greenwich and London Bridge; do your duties take you to London Bridge every day?—Every day.

5845. And you still think that the river at London Bridge is foul and offensive in the summer months?—Yes, in hot weather, and very offensive too.

5846. (*Mr. Bidder, through the Commission.*) Have you any entries in this present year?—No, none at all.

The witness withdrew.

Mr. William Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb., called in; examined by Mr. Balfour Browne.

*Mr. W. Collingridge. M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

5847. I think you are the Medical Officer of Health to the Port of London Sanitary Authority?—I am.

5848. When were you appointed to that office?—In May 1880.

5849. Whom did you succeed?—I succeeded Dr. Harry Leach, who died six months before.

5850. Have you, since your appointment as medical officer, been in the habit of spending much time upon the river during the last two years?—I spend a great deal of time upon the river.

5851. Where does your duty upon the river principally lie?—Principally between Westminster or Waterloo and Purfleet.

5852. Purfleet is just below Erith, is it not?—It is. Those are not the limits of the jurisdiction.

5853. But that is where you are principally occupied?—Quite so.

5854. And those are the parts of the river of which you have had the best opportunity of judging?—Quite so.

5855. Can you say generally what the condition of the river has been during these two years?—During the summer months, more particularly, the river water has been extremely bad. I notice that whenever we have continued hot weather, more than two or three days successively, the water becomes darker in colour, and we get this very offensive smell, that of course being always worse in the neighbourhood of the outfalls; and I also notice these black patches of sewage.

5856. Do you say that the black patches come with any particular state of the weather?—They always come in hot weather.

5857. And they are worse in the neighbourhood of the outfalls?—Yes, in the neighbourhood of the outfalls and above. I have not noticed them, to the same extent, below.

5858. The state of the river you say is very bad; it has been described here as foul, is it also of a dark colour?—Yes.

5859. Can you tell the Commission whether the condition of the river, so far as the eye and sense of smell are concerned, is exaggerated by agitation?—Very much so. You notice that particularly standing behind the paddles of a steamer; there you always notice it even when you do not get it in any other way, when there is really no smell from the water itself.

5860. One of the witnesses told the Commission to-day that occasionally you find the water pretty clear on the surface, but underneath of a much worse character; as far as your experience is concerned, is that true?—Yes; certainly.

5861. You say that it is always worse in dry weather?—Always.

5862. Can you tell the Commission whether it is after a short period of drought and heat that these conditions that you have been speaking of principally appear?—They begin generally, I have noticed, if we have two or three days hot weather. In the very few hot days that we had this year, I think on the third or fourth day after the hot weather, the colour of the water began to change.

5863. You have spoken of its being increased by the stirring up of the paddles, and also of the patches; is it your view that those patches come from below and spread over the surface?—I believe that the patches are caused by the influence of the tide, or some other influence bringing up the sewage mud from the bottom of the water.

5864. How would you describe the patches?—I should describe them as very slightly diluted sewage.

5865. How do you judge of that?—I have taken specimens of these black patches, and taken them to my office in bottles and examined them. They are very thick indeed; there is a very large amount of suspended matter, and the smell from it is horrible. A large quantity of the suspended matter is pure sewage, fæcal matter. These specimens have not been chemically examined.

5866. But you have no doubt of the correctness of your opinion that it is sewage matter?—I have no doubt whatever.

5867. Have you watched the stream as it flows out from the outfalls?—Frequently.

5868. Can that be traced for a considerable distance on the river?—At times. It depends very much upon the state of the weather and upon the direction of the wind.

5869. When it can be traced, what is the character of the stream upon the surface as seen by you?—It is a very dark smooth stream. You can see distinctly the difference between the colour of the stream of sewage and the colour of the river water; and you notice that particularly in cold windy weather, when the river water seems comparatively pure and of a brown colour. You see the two streams running side by side, the brown and the black.

5870. Is there anything clearly distinguishable in that black stream that marks it as being sewage?—Certainly. In the stream you have these small pieces of fæcal matter, which are small as a rule, but some-

times you come upon very large masses; you get matches, paper, and vegetable matter, and a large quantity of corks at times.

5871. Can you tell the Commission how far that stream, which you say is distinguishable from the water of the river, can be traced?—I have traced it downwards, well into Erith Bight.

5872. (*Chairman.*) From the outfalls?—From the outfalls.

5873. (*Mr. Bidder.*) That would be from Crossness, I suppose?—Yes.

5874. (*Mr. Balfour Browne.*) And you say that the colour of that stream contrasts completely with the colour of the water around it?—Yes, very strongly. Of course, as you follow it down, the difference becomes less marked; so that eventually you lose it altogether.

5875. Has the wind less effect upon that stream than it has upon the other water, or more?—It has less effect upon the surface of the water. You see that very well indeed, if you look across the river. When there is sufficient wind to ripple the surface of the river generally, the surface of the sewage stream is perfectly smooth; it has an oily appearance.

5876. (*Sir John Coode.*) To what do you attribute that smoothness?—Simply to the oily or greasy matter in the sewage.

5877. (*Mr. Balfour Browne.*) In fact, this is a great experiment of throwing oil upon the waters?—Exactly; it is a very good instance.

5878. Have you on several occasions watched, and have your deputies watched, the outflow from the outfalls, with the view of finding out how and when it flows?—It was watched.

5879. (*Mr. Bidder.*) Did you watch it?—I watched it during part of the time. I was present during the whole of the night, and I watched the two outfalls at intervals. During the time that I was absent from the outfalls my officers were there in the boat. I went backwards and forwards from one outfall to the other.

5880. (*Mr. Balfour Browne.*) And those officers have been called, I think, already?—They have been called, and have given evidence upon that point.

5881. What are their names?—Lewis and Spadaccini.

5882. One of those occasions on which you were personally present was the 30th of June 1882, I think?—Yes.

5883. Would you tell the Commission what you observed at 7.15 in the evening?—The sewage was running out.

(*Mr. Bidder.*) My learned friend may take it as admitted that there are occasions, though it is contrary to the general practice, when the sewage has been obliged to be let out before the flood.

(*Chairman.*) It may be taken shortly.

(*Witness.*) The 30th of June was one of these occasions.

5884. (*Mr. Balfour Browne.*) From your own personal observation, can you tell the Commission how many times you have seen this?—I have seen it a number of times, but I can only give you a few dates. I saw it on the 16th of last November.

5885. On the 28th of July?—The 28th of July was the date to which you referred when these inspectors were watching the outfalls. On the 30th of June I was down the river on the Conservancy steamer, and the outfall was running then. I think it was just about low water.

5886. You have yourself repeatedly seen the discharge taking place?—I have repeatedly.

5887. What I am referring to particularly is a discharge taking place either just before or on the flood?—Yes; on that date which I gave, viz., November 16th, the discharge was actually on the flood.

5888. Owing to its discharge on the flood, in what direction does it go?—Upwards, certainly, if discharged on the flood.

5889. The object of course of the restriction put upon the Metropolitan Board was that it should all be carried upon the tide going down?

(*Chairman.*) That is scarcely a question to put to the witness.

(*Mr. Balfour Browne, to the witness.*) You can, of course, if my learned friend wishes it, on all these occasions that you have mentioned, give the time of high water at London Bridge as compared with the time at which you saw the sewage flowing?

(*Mr. Bidder.*) It is a well-known fact that the board have already designed increased reservoirs, because there were occasions upon which the reservoirs were not large enough to hold the sewage.

5890. (*Mr. Balfour Browne, to the witness.*) Is it in your experience a rare occurrence that this takes place?—I think not.

5891. (*Chairman.*) You have noticed it on three occasions which you have mentioned, viz., the 16th of November, the 30th of June, and the 28th of July. Were there many more dates on which you noticed it?—Certainly there were more.

5892. Were there three more?—More than that. I must have seen it on at least a dozen occasions.

5893. (*Mr. Balfour Browne.*) Though you have observed it on other occasions, those are the only three days that you can give dates for?—Exactly.

5894. What is the highest point of the river at which you have seen this black discolouration, and the floating fæcal matter going up the Thames, as a distinct stream?—As a distinct stream I have traced it up to Blackwall.

5895. Of course it goes much higher, but you cannot trace it?—Certainly. You can trace actual fæcal matter much higher up, but not as a distinct stream.

5896. (*Chairman.*) When you say a "distinct stream," do you mean a continuous stream?—Not absolutely continuous, but sufficiently so for one to be able to follow it up in a boat.

5897. (*Mr. Balfour Browne.*) I think you have given the date of the 29th of June 1882?—I have not given that date.

5898. Do you remember an occasion when you traced it to Blackwall?—The occasion was during the summer before last, during 1881, and I think it was about the middle of July. I have no record.

5899. In your experience has the state of the river during the last summer been so bad as it was in the previous year, or the year before that?—The last years have been exceptional years. I think the worst state in which I ever saw the river was in 1880. I think it was distinctly worse then than in either this year or last year.

5900. Do you remember what the condition of the river was at the end of June in this year?—It was very bad indeed.

5901. Was there hot weather at that time?—Yes.

5902. However, you say that as far as your term of office has extended the worst period was in July 1880?—Yes, I think it was. There has been very little hot summer weather indeed in the last three years.

5903. Where was it worst in July 1880?—It was worse, of course, in the neighbourhood of the outfalls. After that it was worst at Woolwich, and below Woolwich and below the outfalls, about Jenningtree Point.

5904. Did you at that time think it necessary to report formally to the Conservators of the Thames upon the condition of the river?—I wrote to the Thames Conservancy.

5905. You have not, of course, got that letter, but you have a copy of it which you have supplied to Sir Thomas Nelson?—I have.

(*Mr. Bidder.*) We must have the original.

(*Chairman.*) There is not the slightest objection to having a copy put in if the parties agree to do so, but I object to having a verbal account of the contents of a paper.

(*Mr. Balfour Browne.*) I believe we are lucky enough, in this instance, to have the original, seeing

*Mr. W. Collingridge M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

5 Dec. 1882.

that Captain Fitzgerald, who is an officer of the Conservancy, has it in his possession.

(*Mr. Bidder.*) Of course the witness can give in evidence whatever he has stated in the letter?

(*Chairman.*) That is the material thing.

5906. (*Mr. Balfour Browne, to the witness.*) As a matter of fact, the condition of the river at that time, as detailed in this letter, was what you have been telling the Commission?—It was.

5907. But you thought it so important that you reported it to the Conservators?—I did.

5908. Can you tell the Commission what was the condition of the river in the summer of 1881?—The condition of the river was very much the same in 1881 as it had been in previous years. I do not think it was quite so bad (though there was very little difference) because the weather was not quite so hot, nor did the hot weather last so long.

5909. And you, again, called the attention of the Conservancy to the fact in a letter, which I will not put in?—I did.

5910. I believe on that occasion you also felt it your duty to urge upon the Port Sanitary Committee, of whom you are an officer, the necessity of taking some steps?—I did.

5911. And, I believe, it was after that date that they made the application to the Government which has resulted in this Commission?—Yes.

5912. It was after your report that they applied to the Government?—It was.

5913. I do not know whether you know, as a matter of fact, that they were advised that they had no power to interfere?

(*Chairman.*) Surely that is not material to us.

(*Mr. Balfour Browne.*) It happened, as a matter of fact, to be brought to his knowledge, but we can prove it otherwise.

(*To the witness.*) Apart from these questions of reporting and other matters, is it your view that there is extreme danger——

(*Chairman.*) That is rather putting his opinion into his mouth for him.

5914. (*To the witness.*) Have you any opinion about the state of the river being dangerous in any respect?—I have. I think it is decidedly dangerous. In my opinion it is impossible to pour sewage into a river to the extent to which it is poured in in the Thames without serious danger to health.

5915. (*Mr. Balfour Browne.*) Have you yourself at any time suffered any inconvenience from the state of the river?—I have frequently, in hot weather, been very seriously inconvenienced indeed.

5916. How does it manifest itself?—I have had distinct nausea, and in two or three cases I have had actual vomitting. I frequently get diarrhœa when I have been on the water in hot weather for any length of time.

5917. Can you, as a medical man, say that it is due to the state of the river that you suffer from these symptoms?—I think I can undoubtedly, because I only have these symptoms after I have been on the river in hot weather for any length of time, and I get rid of them by staying, as I am sometimes obliged to do, away from the river for three or four days.

5918. Do you know the mud which is deposited upon the banks, and which is exposed to the atmosphere at low water?—Yes.

5919. What is the character of that mud?—The mud generally is dark slimy black stuff, and has a peculiar gelatinous appearance.

5920. Where particularly do you notice that gelatinous appearance of the mud?—Particularly nearer to the outfalls.

5921. Are you acquainted with the factories and works which are upon the banks of the river in the neighbourhood of the outfalls?—I am.

5922. Do any of those give out offensive smells?—Yes, some of them undoubtedly do.

5923. Can you tell the Commission whether the smells given out by those factories are at all like that which you say comes from the river?—Not in the slightest. The smells given out by the factories are all distinct smells. It is possible in passing down the river to check off the factories as you come to them, provided that the wind is blowing in such a direction as to bring the smells across the river. It is impossible to mistake the smell of the factories for the smell of the sewage.

5924. Is it your duty as medical officer to present half yearly reports to the Port Sanitary Committee of the Corporation?—It is.

5925. When was your first report presented?—I have not the exact date, but it was a report for 1880. It was partly my own report, but the greater part of the report was made up from records. The report which was presented in December 1880 was for the year ending the 30th of June 1880.

5926. (*Chairman.*) You reported facts there which were not within your knowledge?—I did, giving the authority for them in the report.

5927. (*Mr. Bidder.*) That report was principally compiled, I understand, from your predecessor's record?—It was.

(*Mr. Balfour Browne.*) I see in that report you speak of a second and recent outbreak which commenced on September 23rd, 1879.

(*Mr. Bidder.*) That cannot be within his own knowledge.

(*Mr. Balfour Browne.*) We cannot call Dr. Leach, he having passed away, and anything that this gentleman got in his professional duty from Dr. Leach's memoranda or books would be evidence.

(*Mr. Bidder.*) Certainly it would not.

(*Chairman.*) These are matters of public notoriety. If you wanted to establish the fact that there was an outbreak of disease, you would find five hundred people who would be able to tell you that.

(*Mr. Balfour Browne.*) Dr. Leach's report is already in, I understand.

(*Mr. Bidder.*) It is not put in.

(*Chairman.*) What we want from the witness are facts within his own knowledge.

5928. (*Mr. Balfour Browne, to the witness.*) Referring to the report which was made in July 1880, and presented in December 1880, what part of it deals with your own work and your own observation as distinguished from that of your predecessor, Dr. Leach?—Certainly, a very small part of it. I think the only part of the report which is my own has no connexion with this question.

5929. Then January 1881 was the date of your next report, I think?—The next report is the report for the half year ending the 31st December 1880.

5930. So that it would be made in January of the next year?—Yes.

5931. That deals with your own observations, does it not?—It does.

(*Mr. Bidder.*) I certainly object to the witness putting in his reports. Ask him any questions as to facts which he states there and get them in evidence.

(*Chairman, to the witness.*) Looking at that report, are you prepared to state to us that all the facts that are stated there are correct to the best of your knowledge and belief?—I am.

*After some discussion, the witness put in the following extracts from his Reports, and his cross-examination was deferred, in order to give counsel for the Metropolitan Board of Works an opportunity of reading the extracts.*

## EXTRACTS FROM REPORT TO THE PORT SANITARY AUTHORITY FOR THE YEAR ENDING 30TH JUNE, 1880.

### Steam Ship Condor.

A report having been received on May 5th of an outbreak of disease on board the steamship "Condor," belonging to the General Steam Navigation Company, an inquiry was instituted as to the cause of this, and also as to the sanitary condition of the vessel. The outbreak had occurred during a voyage to Charente,

and on the passage home the captain had applied to the quarantine officer at the Motherbank.

Five seamen had been attacked suddenly with a febrile and prostrating malady, and one of them with a fatal result.

The outbreak seemed to have been one of typhoid fever, caused very probably by bad water taken on board during a previous voyage to Stettin.

The sanitary condition of the steamer itself was very good.

### School Ships.

In two only of the seven training ships, containing altogether between two or three thousand young subjects, were any cases of zymotic disease observed in the course of the half year, and the sanitary condition of most of these establishments remained very satisfactory during this period.

On January 23rd, a boy from the training ship "Shaftesbury," lying off Grays, was attacked with scarlet fever whilst under medical treatment in a house used as an infirmary.

Six days later another case appeared on board the ship, and after another interval of a few days a third case.

In the course of February three other cases occurred on board. In these latter cases the fever seems to have been of a very mild character, and its symptoms not very decided.

In the first three cases there were severe and well marked indications of a bad type of scarlet fever; of this small number one was fatal.

Active steps were taken by the captain-superintendent and the medical officer of the ship to prevent extension of the fever, and these were fortunately attended with such success, that what promised to become an outbreak of a very serious character was, in its early stage, most effectually controlled and stamped out.

In this instance considerable difficulty was at one time experienced by the authorities of the "Shaftesbury" in obtaining hospital accommodation on shore for the boys attacked by the fever.

As the ship infirmary in Grays could not (through the conditions under which it had been let) be used for the reception and treatment of cases of infectious disease, it was found necessary to send two of the patients to the Homerton Fever Hospital, but further accommodation here was refused on account of the "Shaftesbury" being placed without the district of the Metropolitan Asylums Board. Ultimately application was made to this authority for the use of the hospital ship "Rhin," to which, after your permission had been granted, the later and mild cases were sent for treatment by your medical officer Mr. Whitcombe.

In consideration of the constant risk of importation of scarlet fever into a school containing many young inmates, and the probability of this affection spreading rapidly and widely in spite of the most vigorous sanitary action, it is, I think, very desirable that every training ship should establish an outlying infirmary, either on the river or on shore, for the sole purpose of the separation and treatment of cases of infectious disease.

Notwithstanding the very favourable sanitary condition of the "Arethusa" training ship, lying off Greenhithe, several isolated cases of typhoid fever were, during the winter, sent from this institution to the Seamen's Hospital at Greenwich.

A full inquiry has been made into the origin of the fever in these instances, but without any satisfactory result.

On March 15th the Local Government Board published an important report of what was supposed to be enteric fever that occurred during October last on board the Reformatory Ship "Cornwall," lying off Purfleet.

As this outbreak, and also a previous one in 1875 of a somewhat similar character, occurred in the district of this authority, and had engaged the attention of your late medical officer, I propose to give here a brief review of the facts connected with the outbreaks in question.

In the second half-yearly report for 1875, your attention was directed by Mr. Harry Leach to the occurrence in September of that year of an extended, though not very fatal, outbreak of fever on board the "Cornwall"; of 258 persons resident in the ship, 120, or nearly 50 per cent., were attached, but, notwithstanding this very large number of cases, two only were fatal.

The epidemic persisted for several months, and did not decline until after the removal, in accordance with the instructions of your medical officer, of the crew to another vessel, and a change of locality from Purfleet to Gravesend.

The boys returned to the "Cornwall" in January 1876, certain structural alterations having been made in the ship with the view of improving its sanitary condition. From that time, up to the commencement of the recent outbreak, the health of all on board seems to have been very satisfactory.

Athough in this outbreak the symptoms in the majority of cases were very mild and obscure, and the mortality was remarkably low, no doubt seems to have been entertained as to the nature of the disease. In the fatal and severe cases the symptoms had evidently been of a "typhoid" character, and as they could not be referred to any other recognised morbid condition, the outbreak was consequently assumed to have been one of typhoid or enteric fever.

By those who subsequently made inquiries on this assumption as to the nature of the outbreak, no satisfactory results could be made out as to its origin. Mr. Leach could not, as stated in his Report, ascertain how or where the boy first attached took the disease, and the medical officer ordered by the Local Government Board in 1877 to make an inquiry was for various reasons unable to complete it.

Certain suggestions were made by Mr. Harry Leach as to the removal and disinfection of the ship, certain structural alterations, improvements in the supply, carriage, and storage of drinking water, which seemed to have been so effectual, that the vessel remained in a satisfactory sanitary condition for nearly four years.

A second and recent outbreak commenced on September 23rd, 1879, and lasted for 30 days, during which period 43, out of a crew of 262 boys and 15 officers, were placed on the sick list.

The majority of these cases, including all that were severe, were at once removed from the ship and treated in a temporary hospital, and 14 cases, most of them being very slight, were sent to the Seamen's Hospital.

In this, as in the previous outbreak, most of the cases were very obscure, and presented very mild symptoms, and in at least 15 instances it was quite clear that the patient suffered from little more than the effects of panic.

Not more than a score of the boys suffered from severe and well marked illness, and there was but one fatal case.

In most of these instances there could be no doubt that the symptoms resembled very much those of typhoid fever, and were not indicative of any other affection known in this country.

From this fact, and also from its similarity to the former outbreak, the nature of which has not been doubted, the second outbreak was also regarded as one of typhoid fever.

This view was based on what was believed to be clear and positive clinical evidence, and notwithstanding such difficulties as the extremely low mortality and the absence of the usual causes of such fever.

At the request of the Home Secretary a medical inquiry was in March last ordered by the Local Government Board. An exhaustive investigation was carried out by Mr. W. H. Power, who furnished a Report upon the subject, to which Report I would refer for further information.

*Mr. W. Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

5 Dec. 1882.

*Mr. W. Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

5 Dec. 1882.

## EXTRACTS FROM REPORT TO 31st DECEMBER, 1880.

### River.

The insanitary condition of the river during the summer has attracted the attention, not only of your officers, but also of the general public.

The water is at all times in a very unsatisfactory condition, and must remain so while such enormous quantities of sewage are thrown into it. During July it became very much worse than usual. Its colour, at all times bad, had become decidedly darker, and it gave a most intolerable smell. Though generally of a dark colour, it had still darker slate-coloured patches over which the odour was more intense. Samples taken from these slate-coloured patches proved them to consist simply of sewage more or less diluted.

Complaints were received from numerous and various sources, both afloat and on shore, and much anxiety was naturally felt lest, with the continuance of hot weather, serious consequences should ensue.

It became a very important point to determine the cause of this unusual pollution, and if possible to take some steps to remove the same.

There could be no doubt that a certain proportion of sewage was derived from the great metropolitan outfalls at Barking and Crossness.

This quantity would of course be increased if the sluices at these places were opened during the flow of the tide. This was asserted to have been the case, but although a watch was kept off these two stations for more than a week, both day and night, no definite proof could be obtained.

This, however, is but one of the very numerous causes of the fouling of the river. There are other very important ones.

Firstly, contamination from the large floating population of the river. This has been estimated at from 15,000 to 20,000 persons. Although much has been done to minimise this by improved arrangements, by providing proper closet accommodation, and by closing up all closets and heads as soon as vessels arrive, still there must always be a seriously and unavoidably large amount of sewage passed into the river from this source alone.

Again, the numerous drains and closets which empty themselves into the river in most of the riparian districts within the jurisdiction of the port.

The number of these is very large. In a special report on the subject in September last I gave the total number as 384.

These, under the River Pollution Act, this authority has power to deal with, and at an early date I intend to bring the subject under the notice of your honourable committee, with a view to taking active steps to close and divert them.

### School Ships.

With the exception of the "Arethusa" and "Cornwall," the health of the school ships has been fairly good.

On the "Warspite" there has been one case of scarlatina and one of typhoid fever.

The typhoid fever occurred at the time when the state of the river was at its worst, and though it is impossible to attribute it to this, still without doubt this in itself was quite sufficient to account for it.

During September there was a renewal of the epidemic of typhoid fever on board the "Arethusa."

This vessel lies off Greenhithe. During the early part of the year several cases had occurred. The disease was of a mild type, and there were no deaths, but still there appeared to be no doubt as to the nature of the outbreak.

| | | | |
|---|---|---|---|
| The 1st case was on | - - | January | 19th |
| 2nd „ | - - | „ | 20th |
| 3rd „ | - - | „ | 23rd |
| 4th „ | - - | February | 7th |
| 5th „ | - - | „ | 12th |
| The 6th case was on | - - | March | 26th |
| 7th „ | - - | April | 5th |
| 8th „ | - - | „ | 23rd |
| 9th „ | - - | May | 7th |
| 10th „ | - - | „ | 23rd |
| 11th „ | - - | August | 31st |
| 12th and 13th „ | - - | September | 6th |
| 14th „ | - - | „ | 16th |
| 16th and 17th „ | - - | „ | 18th |

There were thus 17 cases in all, with a decided break in the series during June, July, and August.

It was obvious from this remarkable succession of cases that there were some unfavourable circumstances affecting the ship, and it became a matter of the utmost importance to make a thorough and complete investigation.

The diet scale is extremely good, no salt meat or pork being issued; the provisions appear to be all of a first-class character.

The drinking water is of excellent quality, derived from a spring in the chalk some distance from the river.

Moreover, the food and water are exactly the same as supplied to the "Chichester," which lies but a very short distance above the "Arethusa," and on which no cases have occurred.

The latrine accommodation is good, and always kept in a clean and proper condition.

It seemed, therefore, that the cause must lie in the ship itself.

After a thorough examination the only weak point that I could attach importance to was the ballasting of the ship.

The ballast is shingle, and it seems to me to be objectionable in several ways.

In the first place, it is very light, and therefore takes up a large space, which would otherwise be available for purposes of ventilation.

Secondly, it is difficult to move, and hence the occasional shifting, and exposure of all parts of the vessel to the air cannot be carried out. This I consider a very important point. Then, again, damp may exist and decomposition occur, the more dangerous, inasmuch as it is hidden from sight.

There is one other possible cause of danger to the health of the ship. It is moored opposite a small creek into which several houses drain.

As, however, there had been no cases of enteric fever on shore, this particular outbreak cannot be assigned to this cause.

With the sanction of your Committee, I advised the authorities to remove the shingle ballast and substitute for it pig iron.

This, however, on account of the great cost (800*l.* or 900*l.*) they were unwilling to do, but have carried out sundry other improvements which I had suggested.

It has since been decided to use the "Chichester" for a time as a drill ship only, and to berth her crew, 70 in number on board the "Arethusa" which will thus have her complement raised to 270.

### "Cornwall."

During November an epidemic of typhoid fever prevailed on board the "Cornwall," which is stationed off Purfleet.

Several previous epidemics have attacked the same vessel. In my last report I gave a brief resumé of these several epidemics, and stated all that was known as to their probable cause and nature.

The last outbreak has been of a more decided character.

Twenty-one have suffered, and several of them severely, but happily only one death has occurred.

I carefully watched as far as possible those who were attacked, and came to the conclusion that they were undoubted cases of typhoid or enteric fever, which opinion was confirmed by Dr. de Brent, the medical officer in charge of the ship.

I have thoroughly examined the vessel and can find in her no sanitary defect or possible cause for the fever.

The drinking water is of excellent quality, and is brought off from the shore by a flexible hose.

Samples taken at the commencement of the epidemic gave very satisfactory results on analysis, while others, taken since, betray a large amount of organic material. This was satisfactorily accounted for by the careless manner in which the samples had been collected; fresh analyses are at the present time being made.*

As a measure of precaution, pending the elucidation of this important point, Captain Morrell, R.N., has wisely had all water boiled before issue.

Those boys infected were at once removed to the infirmary, a suitable iron erection about a mile off, where they were tended by Dr. de Brent, assisted by an efficient staff; very strict sanitary precautions were observed, and the outbreak speedily arrested. A post-mortem was held on the boy who died, which proved beyond a doubt that the epidemic was one of typhoid fever.

It seems that with this unfortunate history of repeated outbreaks there must be something radically wrong, and I am inclined to attribute much of the blame to the position of the vessel. She lies off Purfleet in a bight, and the stream during the ebb, after striking the opposite point, sets directly into this bay. At ebb the current carries down the great volume of sewage from the metropolitan outfalls with it. This can be seen occasionally as a dark line on the water, while at all times evidences of sewage can be found in the mud on the foreshore; moreover, it has been proved by analysis that during the ebb the water on the north shore at this point contains a very much larger amount of ammonia in combination than that on the south shore.

It seems only necessary then to have typhoid fever in London, and then as a direct consequence the germs are carried through our sewers, through the metropolitan outfalls, straight into the river, and thus naturally find their way to Purfleet.

It has been fairly well established that the poison of typhoid fever is practically innocuous at the time it leaves the body, but that about the third day after decomposition has set in it becomes highly dangerous. Obviously this would be about the stage which the germs carried to Purfleet would have reached. Whatever danger there might be to the health of the vessel from the state of the river water would be greatly increased by the practice of washing decks with it. This objectionable plan has now been entirely given up.

Under these circumstances, it is hardly, I think, a matter of much surprise if outbreaks should from time to time occur.

Our legislature, in sanctioning the pollution of our great water highway by the discharge of enormous quantities of sewage, must bear the responsibility of conveying disease therewith.

If the constant outpouring of sewage continues, it will become, sooner or later, a grave question whether the Thames will any longer be a proper or safe river for stationing our training ships.

## EXTRACTS FROM REPORT TO THE 30TH JUNE, 1881.

### The River.

The condition of the water still continues, as it must while the sewage of the metropolis is poured into it, a source of great anxiety to all concerned with the health of those engaged thereon.

Public attention is being gradually drawn to the serious error committed in throwing such valuable material into the great water highway, and a strong feeling is growing up, that sooner or later arrangements must be made more consistent with common sense and the present state of sanitary science.

At present, however, these are protected by law, and your authority has hitherto contented itself with the minor causes of pollution. During February your Committee sanctioned the addressing of a letter to those Riparian Authorities who allowed sewage to flow into the Thames from their district, calling upon them to discontinue the same. (*See* Appendix L.)

This letter produced, as was expected, very important changes in the sewage outfalls of the Upland Riparian Authorities.

Chiswick has constructed a large main sewer, and diverted from the river a large number of outfalls at Strand-on-the-Green.

In Twickenham several outfalls have been diverted, and we are informed by the authorities that in a few months all will have disappeared.

In Chelsea the vestry issued notices to all owners of property where these nuisances existed calling upon them to divert forthwith.

St. George's, Hanover, diverted the only foul outfall it possessed.

The City, also, has removed its only one at London Bridge.

Poplar.—The Board of Works have diverted a certain number. With regard to the others, they object that the outfalls are on premises where there is no sewer within 200 feet, and that, therefore, they have no power to compel connexion.

Woolwich.—The one closet emptying into the river in this district has been pulled down.

Battersea.—Two foul outfalls have been diverted and notices served on five owners of property where others exist. As no answers were received from Isleworth, Fulham, Westminster, Whitechapel, Limehouse, West Ham, Barnes, St. Saviour's, Rotherhithe, Greenwich, and Charlton, it was considered advisable by your Honourable Committee that a second communication should be sent to them. This was done on April 11th (*see* Appendix L.) with the following results.

Fulham reported that in several cases the owners of premises draining into the river have had proceedings taken against them and the outfalls closed, and that action against others will follow.

Westminster.—The necessary works are in hand.

Whitechapel.—The only foul outfall has been diverted.

Limehouse.—Notices have been served upon the owners of property where the outfalls have not already been diverted.

St. Saviour's.—The clerk reported that all the foul outfalls in this district have been intercepted or stopped, with the exception of one discharging surface water, and which is innoxious.

It will thus be seen that there is a decided tendency on the part of these various authorities to comply with the requirements of the Port Sanitary Committee, and though, doubtless, some of these reports are not strictly carried out, still it is certain that by the action of your Honourable Committee much pollution of the river has been prevented.

St. Olave's.—The medical officer wrote, "that as at "present advised the Board does not consider it has "any power." As the course of this authority seemed perfectly clear the correspondence was handed to the City solicitor to advise and report thereon.

On the 12th May his report was received, giving as his opinion that sanitary authority in this Act is defined as, "any urban or rural sanitary acting in the "execution of the Public Health Act, 1875," and that, therefore, Port Sanitary Authorities are not included in the term sanitary authority to whom the enforcement of the provisions of the Act is given by the 8th section. (*See* Appendix L.)

In view then of this opinion it was clear that no further proceedings could be taken. It must, however, be a matter of great satisfaction that so much has been accomplished without the assistance of legal proceedings.

### The Training Ships.

The health of the training ships during the past six months has been exceptionally good, not one case of infectious disease having occurred on any of them.

* Since this Report has been printed, the results of these analyses have been obtained, and show the water to be above all suspicion of having caused the disease.

*Mr. W. Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

5 Dec. 1882.

This is remarkable, as the number of boys on all these vessels averages about 1,750, and these all at a time of life most susceptible to the influence of zymotic disease.

During a very heavy gale in January last the "Shaftesbury" was carried away by the force of the wind and ice and thrown upon the shore. Happily no serious injury was sustained by either staff or boys, and owing to the excellent discipline no confusion occurred.

The vessel was towed off by tugs, and after a short stay at Greenhithe was taken into the Royal Albert Docks, where she was repaired.

## APPENDIX L.

Port Sanitary Offices,
Greenwich, S.E.,
14th February 1881.

To the Medical Officer of Health
to the Sanitary Authority of the District of

SIR,

I AM instructed by the Port of London Sanitary Authority to call your attention to the enclosed list of foul outfalls into the River Thames within your district.

The existence of these outfalls being contrary to the provisions of the Rivers Pollution Act (39 & 40 Vict. c. 75.), and being one of the principal causes of the insanitary condition of the river, I require you to divert the same forthwith, or to use them only for storm or clean water.

I am, &c.
(Signed) WILLIAM COLLINGRIDGE,
Medical Officer of Health,
Port of London.

Port Sanitary Offices,
Greenwich, S.E.,
11th April 1881.

To the Medical Officer of Health
for the District of

SIR,

ON the 14th of February last, by the direction of the Port of London Sanitary Authority, I wrote to you calling attention to the foul outfalls into the river, and requesting diversion of the same. Up to the present date only a formal acknowledgment has been received. Will you kindly let me know what action the Local Board is taking in the matter.

I am, &c.
(Signed) W. COLLINGRIDGE,
Medical Officer of Health,
Port of London.

## APPENDIX M.

(Copy.)

To the Worshipful the Port of London Sanitary Committee.

GENTLEMEN,

I HAVE considered the papers referred to me by your order of the 5th April, relating to certain foul outfalls in the district of St. Olave, Southwark, going into the River Thames, and I am of opinion that the Port Sanitary Authority have no jurisdiction to interfere in the matter.

The Statute 39 & 40 Vict. c. 75. (being the "Rivers "Prevention Pollution Act, 1876"), defines Sanitary Authority to mean in that Act "any Urban or Rural "Sanitary Authority acting in the execution of the "Public Health Act, 1875," and it is clear therefore that Port Sanitary Authorities are not included under the term "Sanitary Authority," to whom the enforcement of the provisions of the Act is given by the 8th section.

I have, &c.
(Signed) T. J. NELSON,
City Solicitor.

Guildhall,
May 12th, 1881.

## REPORT PRESENTED 15TH DECEMBER 1881.

Port Sanitary Offices,
Greenwich, S.E.,
December 8th, 1881.

To the Chairman and Members of the Port Sanitary Committee.

MR. CHAIRMAN AND GENTLEMEN,

I BEG herewith to hand you, in a rough form, the results of the investigation of the sub-committee appointed to inquire into the condition of the river, and the analyses of samples of water taken by them. These analyses I have arranged in a tabular form in such a manner that they can be easily compared with one another, and also with one or two other well-known waters.

The condition of the Thames generally is naturally very different at this season from that in the summer.

This obviously depends upon several causes; in the first place the sewage itself contains a much larger amount of storm water; secondly, the river receives more water from the upland districts; and lastly, the effect of continued high temperature materially assists in the decomposition of organic matter.

Your Committee were of necessity then prepared to find the water in a better state than if the investigation had been carried on during the summer. The whole of the river has been inspected—the lower part, viz., from Gravesend to Woolwich, on November 23rd, and the upper part, as high as Teddington Lock, on December 3rd. Barking Creek was specially inspected on December 20th, and Bow Creek on December 12th.

On each occasion samples of water were taken at various points, and these submitted to careful analysis by your medical officer.

Some of them were also handed to Professor Wanklyn, with the object of obtaining an independent and therefore a confirmatory result.

The details of the analysis were found to agree fairly closely, with one exception, viz., the estimation of the total solids where there is a wide divergence. This is explained by the fact that Professor Wanklyn reduced these at a low red heat, while your medical officer employed a temperature under 212° Fahr.

The sample taken at Teddington shows the state in which the river water exists at the commencement of your jurisdiction.

It contains a very small amount of solids and chlorine, and a fairly small quantity of ammonia, and is described by Professor Wanklyn as "impure, but "impurity probably of vegetable origin."

Thus at London Bridge, although the total solid residue is small (24·6 grains according to Professor Wanklyn, and 38 grains in a gallon according to your medical officer), still there is a large proportion of organic matter, and the water is clearly charged with sewage.

As the water is traced down it is found to gradually increase in impurity as it receives the sewage of riparian districts.

At the metropolitan outfalls at Barking and Crossness this impurity becomes much more marked.

The worst specimen examined was the one taken at Barking on 23rd November when the tide was running down, and which is reported to contain about one fifth of its volume of sewage. The Crossness, although very bad, is a great improvement on this.

Lower down still, owing to the enormous dilution, and the influence of oxidation, the river again becomes much less foul, and a sample taken off Tilbury is said to be "practically uncontaminated with sewage." The series of results is an extremely interesting and instructive one, and show clearly the very great influence the outfalls have in polluting the stream.

It is an unfortunate point, however, that this effect has been so much exaggerated, inasmuch as the mere exaggeration weakens any argument in support of this view.

*Mr. W. Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

5 Dec. 1882.

Whatever may be the results of analyses, and the inspection of the river at this season, there can, however, be no doubt with those who are in the habit of travelling on the Thames during the hot weather, as to the extremely foul state of its waters, and there is abundant evidence to show that at any rate some part (and that by no means a small one) of its offensiveness is due to the discharge of the sewage by the Metropolitan Board of Works.

And it is the more important to state this inasmuch as the amount of sewage is constantly increasing, as shown by the following Table :—

SEWAGE DISCHARGED at OUTFALLS, 1869 to 1878 inclusive.

| Rainfall. | Year. | Gallons per Year. | |
|---|---|---|---|
| | | Crossness. | Barking. |
| 27·93 | 1869 | 17,574,292,274 | 12,793,513,197 |
| 18·89 | 1870 | 16,678,226,567 | 14,633,751,920 |
| 26·44 | 1871 | 18,497,165,385 | 20,112,448,713 |
| 32·88 | 1872 | 22,281,418,356 | 23,137,747,554 |
| 24·31 | 1873 | 21,878,839,124 | 22,680,778,594 |
| 24·12 | 1874 | 20,544,185,537 | 22,610,777,770 |
| 29·28 | 1875 | 23,505,775,239 | 26,955,262,659 |
| 28·90 | 1876 | 22,370,124,831 | 27,751,403,034 |
| 29·26 | 1877 | 26,008,009,706 | 29,995,714,676 |
| 29·26 | 1878 | 27,317,822,594 | 30,177,765,147 |
| 271·27 | 10 years | 216,655,859,613 | 230,849,163,264 |
| Average per year. 27·1 | | 21,665,585,961 | 23,084,916,326 |
| Average per diem. — | | 59,357,769 | 63,246,346 |
| | | Together 122,604,115 | |

Showing an increase of about 14 per cent. in 10 years, with a practically uniform rainfall.

There can be no question, if one may judge by the literature of the subject, that the condition of the Thames has much improved since the Metropolitan Board of Works have carried the sewage down to Barking and Crossness, but the fact still remains that our mode of disposal by throwing it in our great water highway and polluting it to an enormous extent, is a disgrace to our vaunted civilisation.

But beyond the Board of Works is the question of the sewage of other riparian authorities.

The position of the Port Sanitary Committee with regard to this matter has at length been clearly defined. Legal opinion having been obtained, it is decided that they have no authority under the Rivers Pollution Act.

There can be no question about this decision, and the situation is certainly an anomalous one.

The Thames, the largest and certainly most important of all our rivers, is to remain the only exception to the law which rightly considers pollution of a stream as a serious offence.

True, other bodies have power to a certain extent, but these are so limited and hampered as to be practically inoperative where most needed.

Later on this must become a question for serious consideration.

In order to show the extent of this riparian pollution, I append a list of foul outfalls.

Inasmuch as a large sum is to be shortly expended in constructing a new reservoir at the outfalls, it would certainly seem advisable that an inquiry by the Home Secretary should be urged upon him by this Committee before these works be undertaken.

Many riparian authorities and inhabitants are prepared to assist in any such proceeding, and abundant evidence is forthcoming as to the existence of a great and offensive nuisance.

I have, &c.

(Signed) WILLIAM COLLINGRIDGE,
M.B., S. Sc. Cert. Camb.,
Medical Officer of Health,
Port of London.

LIST of FOUL OUTFALLS into THAMES within the Jurisdiction of Port Sanitary Authority.

1881. North side.

| District. | Number. | |
|---|---|---|
| Teddington | — | |
| Twickenham | 6 | |
| Isleworth | 11 | |
| Brentford | 22 | |
| Chiswick | 6 | |
| Fulham | 21 | Jurisdiction of Metropolitan Board of Works. |
| Chelsea | — | |
| St. George's, Hanover Square | 2 | |
| Westminster | 6 | |
| Strand | — | |
| City | 2 | |
| Whitechapel | 3 | |
| Limehouse | 29 | |
| Poplar | 41 | |
| West Ham | 14 | |
| East Ham | — | |
| Woolwich | 3 | |
| Barking | 2 | |
| Romford | 2 | |
| Rainham | 2 | |
| Gray's Thurrock | 14 | Port of Malden and Port of Colchester — no shore boundaries. |
| Shadwell | 1 | |
| Total | 187 | |

LIST of FOUL OUTFALLS into THAMES within the Jurisdiction of Port Sanitary Authority.

1881. South side.

| District. | Number. | |
|---|---|---|
| Ham, Rural | — | |
| Petersham and Ham | — | |
| Richmond | 19 | |
| Barnes | 33 | |
| Wandsworth | — | Jurisdiction of Metropolitan Board. |
| Battersea | 7 | |
| Lambeth | 2 | |
| St. Saviour's, Southwark | 4 | |
| St. John's and St. Olave's | — | |
| Bermondsey | — | |
| Rotherhithe | 19 | |
| Greenwich | 23 | |
| Charlton | 1 | |
| Woolwich | 13 | |
| Plumstead | 1 | |
| Erith | 12 | |
| Dartford | 10 | |
| Northfleet | 9 | |
| Gravesend | 29 | |
| Port of Rochester | — | No shore boundaries. |
| Port of Faversham | — | |
| Port of Ramsgate | — | |
| Total | 182 | |

ANALYSIS and SUMMARY.

Above the jurisdiction of the Metropolitan Board of Works :—

| | |
|---|---|
| North side | 45 |
| South side | 52 |
| Total | 97 |

Within the jurisdiction of the Metropolitan Board of Works :—

| | |
|---|---|
| North side | 121 |
| South side | 70 |
| Total | 191 |

Below the jurisdiction of the Metropolitan Board of Works :—

| | |
|---|---|
| North side | 21 |
| South side | 60 |
| Total | 81 |

Grand total, Foul Outfalls opening in Port Sanitary Authority's district - 369

*Mr. W. Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

5 Dec. 1882.

## Analyses of Samples of Thames Water, 1881.

| Number. | Date. | Position. | Depth. | Time. | Wind. | Total Solid Residue, Grains per Gallon. | | Chlorine, Grains per Gallon. | Parts per 1,000,000. | | — |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | — | Loss on Ignition. | | Free $NH_3$. | Alb. $NH_3$. | |
| 1 | Dec. 3 | Teddington Weir | about 3 feet | 12.40 | S.W. | *19·5 | — | 1·2 | ·14 | ·20 | Professor Wanklyn |
| 2 | ,, | ,, | ,, | 1.15 | ,, | 28 | 7 | 1·2 | ·2 | 1·5 | |
| 3 | ,, | Richmond | ,, | 12.40 | ,, | 24 | 8 | 1·2 | — | — | High water London Bridge, 11.56 a.m. |
| 4 | ,, | Chiswick | ,, | 12.5 | ,, | 15 | 5 | 1·3 | — | — | |
| 5 | ,, | Hammersmith Bridge | ,, | 12 0 | ,, | 15 | 6 | 1·4 | — | — | |
| 6 | ,, | Westminster Bridge | ,, | 11.5 | ,, | 58 | 44 | 1·6 | — | — | |
| 7 | ,, | London Bridge | ,, | 10.40 | ,, | 38 | 18 | 2·4 | 1·16 | 1·75 | |
| 8 | ,, | ,, | ,, | ,, | ,, | *24·6 | — | 3·0 | ·24 | ·32 | Professor Wanklyn |
| 9 | Dec. 12 | Bow Creek (head of creek) | 2 feet | 3.35 | S.S.W. | 28 | 15 | 8 | — | — | Ditto, 6.4 p.m. |
| 10 | ,, | ,, (West Ham pumping station) | ,, | 4.20 | ,, | 28 | 16 | 6 | — | — | |
| 11 | ,, | Mouth of creek | 2 ft. 6 in. | 4.35 | ,, | 36 | 17 | 4 | — | — | |
| 12 | Nov. 23 | North Woolwich | 3 feet | 4.45 | N.S.W. | 616 | 297 | 204 | 1·47 | ·22 | |
| 13 | ,, | ,, | ,, | 4.50 | ,, | *377 | — | 195 | 2·00 | ·20 | Professor Wanklyn |
| 14 | ,, | Barking | ,, | 4.15 | ,, | 831 | 375 | 260 | 4·96 | 1·06 | Ditto, 2.51 p.m. |
| 15 | ,, | ,, | ,, | 4.20 | ,, | *570 | — | 280 | 5·00 | 1·00 | Professor Wanklyn |
| 16 | Dec. 20 | ,, (mouth of creek) | ,, | 11.5 | ,, | 45 | 40? | 18·2 | 1·34 | 1·10 | |
| 17 | ,, | Barking Creek | ,, | 11.15 | N.W. | 28 | 13 | 30·1 | — | — | Ditto, 1.5 p.m. |
| 18 | ,, | Barking Town | ,, | 1.5 | ,, | 32 | 14 | 14 | ·8 | 1·30 | |
| 19 | Nov. 23 | Crossness | ,, | 3.50 | N.S.W. | 1076 | 507 | 340 | 2·10 | ·85 | |
| 20 | ,, | ,, | ,, | 4.0 | ,, | *623 | — | 340 | 2·00 | ·60 | Professor Wanklyn |
| 21 | ,, | Erith, five feet from pier head | ,, | 3.20 | ,, | 1757 | 825 | 585 | — | — | |
| 22 | ,, | "Cornwall," inside Purfleet | ,, | 3.0 | ,, | 2566 | 479 | 607·5 | ·854 | 1·42 | |
| 23 | ,, | Greenhithe, inside "Worcester" | ,, | 2.30 | ,, | 1704 | 496 | 712 | — | — | Ditto, 2.51 p.m. |
| 24 | ,, | Grays, outside "Shaftesbury," 150 yards from | ,, | 2.15 | ,, | 2153 | 778 | 810 | 1·4 | ·86 | |
| 25 | ,, | Gravesend, off Town Pier | ,, | 1.40 | ,, | 2425 | 925 | 846 | ·12 | ·148 | |
| 26 | ,, | Off Tilbury, mid-channel | ,, | 1.30 | ,, | 2342 | 763 | 984 | ·066 | ·09 | |
| 27 | ,, | ,, ,, | ,, | ,, | ,, | *1780 | — | 940 | ·06 | ·08 | Professor Wanklyn |
| 28 | — | Sewage from Crossness | — | — | — | 57 | 21 | 18·2 | — | — | |
| 29 | — | Sewage from West Kent Outfall (filtered) | — | — | — | 54 | 23 | 6·3 | — | — | |
| — | — | London water supply: Thames | — | — | — | 18·5 | — | 1·2 | 0·01 | 0·06 | |
| | | London water supply: New River | — | — | — | 17·1 | — | 1·1 | 0·00 | 0·06 | |
| | | London water supply: Kent Company's | — | — | — | 26·5 | — | 2·1 | 0·01 | 0·02 | |

* The solids were dried at a temperature bordering upon a low red heat.

William Collingridge, M.B., S. Sc. Cert. Camb.,
Medical Officer of Health, Port of London.

Remarks by Professor Wanklyn on analysis of above samples :—

No. 1 is impure, impurity probably of vegetable origin.

No. 8 is very impure, being apparently charged with sewage.

No. 27 is mixed sea and river water, and is practically uncontaminated with sewage,

Nos. 20, 15, and 13 are also mixtures of sea and river water contaminated with sewage, 15 more than 20, and 13 rather less so.

No. 15 is very largely contaminated, and contains about one fifth of its volume of sewage.

J. Alfred Wanklyn,
Laboratory,
7, Westminster Chambers.

## EXTRACTS FROM REPORT TO 31st DECEMBER 1881.*

The number of foul cargoes dealt with according to their nature is, however, somewhat high. These consist chiefly of loads of manure and other refuse, and while in the interests of trade they must be allowed to pass to and fro on the river, it is the province of your officers to endeavour, as much as practicable, to minimise the nuisance arising therefrom.

### The State of the River.

The condition of the water of the Thames, always bad, of necessity is far worse in the summer than in the winter.

Naturally, as the population of London increases the amount of sewage becomes larger, and therefore whatever nuisance exists now must tend to be augmented every year.

That this is a nuisance denied by many persons can have no bearing on the actual facts.

During the first week in July the temperature was unusually high, and as any one accustomed to the river could have prophesied, its condition became exceedingly foul.

The water was of dark colour, and the smell therefrom intolerable. Every person who had business upon the river or its banks was unfortunately only too well aware of this. Moved by this abominable and disgraceful state of things, your Committee appointed a sub-committee to inquire into the matter.

This sub-committee investigated the subject, and a report with analyses, &c. has been already circulated, and is appended hereto.

But I would submit that this is not a matter for delicate chemical analyses, but rather one which any person possessed of ordinary sense of sight and smell is perfectly competent to give an opinion upon.

Fresh unmistakable fæces float upon the surface of our great river, and certainly this must be considered by every one to be a disgrace to the nation.

Public opinion and public indignation are at length being roused, and several very influential riparian authorities are prepared to second the efforts of the Corporation, and urge upon the Home Secretary those powers with which he is entrusted by Act of Parliament.

To a petition which was presented during August upwards of 13,000 signatures were appended, and these all of persons actually connected with the river.

The Port Sanitary Authority has done all in its power to prevent pollution. Many closets and foul outfalls have been closed or diverted by its action, but unhappily it has been decided to have no power under the Rivers Pollution Act, 1876, the only Act which could really strengthen its hand.

One part to which attention has been more particularly called is Limehouse Creek. Here a nuisance was found to exist, caused by the drifting of foul material floating, by the bad condition of the river mud, and also to some extent by the presence of closets and other foul outfalls.

On communicating with the medical officer of health of the Limehouse district, Dr. G. A. Rogers, I was informed that the Board had decided to make a clean sweep of all foul outfalls into the river, and that a new sewer had been constructed for this purpose. A large number have been already diverted, and the remainder will disappear as soon as their existence has been proved by your officers.

This is a great step in the right direction, for there can be no question that if all the foul outfalls from districts above Barking and Crossness were diverted, the state of the river would be to a certain extent improved.

But, unhappily, there would then still remain the outfalls of the Metropolitan Boards, undoubtedly the principal offenders.

### Other Infectious Diseases.

Considering the number of vessels which constantly enter the port, and the extremely unsanitary condition of many of the ports from whence they come, it is a matter for great congratulation that so few cases of infectious disease should be discovered.

On the 12th July a case of remittent fever was removed from the "Poonah" to the Seamen's Hospital.

On October 1st information was received of the existence of typhoid fever on the "Alsatia," which was coming up the river.

She was accordingly met as she entered the docks, and the patient at once removed to hospital.

This early notification arose from the prompt action of the Customs officials at Gravesend, who report all cases immediately they come under their notice.

This is of inestimable value to your authority, inasmuch as it completely obviates the necessity of having officers on duty at Gravesend to board every vessel, a proceeding which would only be necessary if we were threatened with an invasion of some epidemic such as cholera or plague.

### School Ships.

The health of boys on the various training ships in the river has been extremely satisfactory, there having been almost complete immunity from infectious disease.

During October two cases of scarlet fever occurred on the School Board Ship "Shaftesbury."

They were at once isolated and sent on board the "Rhin." One or two suspected cases were also immediately sent on shore, and by these prompt measures any further spread was prevented.

The vessel was at the time increasing her complement of boys, and new boys were being sent straight from their homes to the ship. It seems highly probable that in this way infection was conveyed to the ship, a source of danger which might be easily avoided by causing all new arrivals to perform "quarantine" of inspection," for ten days or a fortnight, at some building set apart for that purpose on shore.

## EXTRACTS FROM REPORT PRESENTED 5th OCTOBER 1882.

### Training Ships.

The general health of the boys on the training ships in the river has been remarkably good. In January a case of scarlet fever occurred on board the "Cornwall," for which no obvious cause could be ascertained.

About the same time, too, appeared a solitary case of measles on the same ship. The usual strict precautions as to immediate isolation, medical inspection of boys, and fumigation, were promptly carried out, and the disease disappeared, the health of the ship continuing perfect until the 12th of April, when another boy was attacked.

Here again it seemed impossible to trace with any degree of certainty the source of the infection. About a month ago a third, and happily the final case occurred, which, in all probability, must have arisen from the second.

* Date of Report 4th January 1882.

*Mr. W. Collingridge. M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

5 Dec. 1882.

### The River.

The continued representations of your Committee, and the public attention drawn to the highly polluted state of the river, have induced Her Majesty's Government to appoint a Royal Commission "To inquire "into, and report upon the system under which sewage "is discharged into the Thames by the Metropolitan "Board of Works; whether any evil effects result "therefrom, and, in that case, what measures can be "applied for remedying or preventing the same." This Commission has already commenced its sittings, and has taken a large amount of evidence bearing upon the question.

With a view to obtaining definite information as to the opinions of those living or having business upon the river, as to whether any nuisance existed, a circular was printed, and sent to the principal shipowners, brokers, agents, and merchants, who would be likely to have any personal knowledge of the river. *See* Appendix K. A large proportion of those addressed replied, and, as might have been expected, were almost unanimous in their expression of opinion that a serious nuisance was caused by the outflow of sewage.

It is, however, right to state that, owing to the exceptionally low temperature during the early part of the summer, and the large amount of rainfall, there has been less nuisance than is usual during the hot months of the year. During the last week of June the water again, however, assumed what may be called its summer condition; the colour became distinctly darker, and a faint sickly smell was clearly distinguished.

While attention is naturally drawn to the principal sources of sewage contamination by the outfalls at Barking and Crossness, attempts have been made with success to induce other sanitary authorities to discontinue discharging their quota into the river. In the Limehouse district alone no less than 12 foul outfalls have been recently removed, and the Local Board have decided to serve notices compelling diversion on those owners who still continue to pollute the river.

A communication has been received from the Whitechapel Board of Works, stating that in compliance with the request of the Port Sanitary Authority the last foul outfall into the river had been diverted. Thus leaving one more clean district.

The Local Board of St. Saviour's also having examined their district, and proved the accuracy of the list of foul outfalls presented by your medical officer, have pledged themselves to remove the same with the least possible delay.

These three districts show a most important advance during the half year, and such clearing up will prove most valuable in discriminating between the great sources of pollution and the smaller ones, and in indicating how exceedingly small the latter are by comparison.

Port of London Sanitary Offices,
Greenwich, S.E.,
March 15th, 1882.

Sir,

I am instructed by the Port Sanitary Committee of the Corporation of London to ask you to kindly furnish them with any evidence you may be able to give as to the pollution of the River Thames by sewage.

The chief points on which information is sought are:—

(i.) As to whether, in your opinion, any such nuisance exists.

(ii.) In what parts of the river and at what times is such nuisance most marked.

(iii.) Any evidence as to its effects on health of those engaged on or near the river.

Such information, if precise, and accompanied by names and addresses of the persons responsible for it, will be most valuable, and cannot fail to be of great public service in the event of any inquiry being held on the subject.

I am, &c.

(Signed) William Collingridge,
Medical Officer of Health,
Port of London.

Mr. Thomas Long called in; examined by Mr. Lumley Smith.

*Mr. T. Long.*

5933. I believe you are a waterman on board the "Conservator," which is in the service of the Thames Conservancy?—Yes.

5934. Have you been much on the Thames?—Yes, all my life nearly.

5935. Have you ever found that being on the Thames in any way affected your comfort or your health?—Yes, several times.

5936. Will you tell me when you remember that it affected your health?—In July 1880, one morning we were under weigh between 3 o'clock and half-past, and the water was very bad that morning; in fact we all felt sick. It affected everybody on board the boat.

5937. Amongst the rest of the people did it affect you?—Yes.

5938. Were you actually sick, or did you merely feel sick?—I felt sick. I had a nasty heaving, but I could not bring anything off my chest.

5939. What time of the day was it?—About 4 o'clock in the morning.

5940. Would that be when you were first starting?—Yes.

5941. Whereabouts was your ship?—At East Greenwich then.

5942. Had you known that to happen on other occasions before?—Yes, several times I felt as if I could be sick through the stench of the water.

5943. Was there anything in your health apart from the stench of the water that would account for your feeling in this way?—No, not the least. I always enjoy good health as a rule.

5944. Then you say that from the stench of the water you have felt yourself qualmish?—Yes, qualmish.

5945. That was in July in 1880; the river was pretty bad then, was it?—Yes, very bad; the worst, I think, I have known it.

5946. Did you notice what it looked like?—You could see lumps of stuff rise from the bed of the river, and then they would break open, and a fearful stench came from them when they broke open; all black mud stuff.

5947. Did you see them come up?—You could see them come up.

5948. You could see them come to the surface?—Yes.

5949. And then they break up, and this nasty smell comes from them?—Yes.

5950. I believe you were sent by Captain Fitzgerald in August 1881, to take some samples of water for him, were you not?—Yes.

5951. Who went with you?—George Lamerton, another waterman.

5952. I believe you went to the southern and northern outfalls?—Yes.

5953. Have you anything to fix the dates?—Yes.

5954. First of all did you report to Captain Fitzgerald each morning after you had been down there?—Yes.

5955. You went at different times of the day, did you not?—Mostly at night tides.

5956. And then you reported in the morning?—Yes.

5957. Did you take any notes at all?—Yes, just rough notes.

5958. What was the first day that you went?—The 17th of August 1881, I went to the southern outfall.

5959. Will you just read your note?

5960. (*Mr. Michael.*) Is that the note you took at the time?—No, not on the paper; I took it in a book.

5961. Where is the book?—I have only taken the rough note.

5962. (*Chairman.*) Have you got your book?—Yes (*producing a book, and handing it to Mr. Michael*).

5963. (*Mr. Michael.*) This was all written at the same time, was it not?—Every day that we went down it was written.

5964. (*Chairman.*) What did you find?—On the 17th of August we went to the southern outfall and took a sample of the water at high water, 7.20 p.m.

5965. (*Mr. Lumley Smith.*) Have you any note of what the sample was like?—The sample was very clear.

(*Mr. Michael.*) There is not a word in your book about the sample being clear. (*The book was handed to the witness.*)

5966. (*Mr. Lumley Smith.*) Read your note of the 17th?—"On the 17th we went to the southern out-"fall and took a sample of the water there at high "water at 7.20 p.m.," and the sample was clear, I have got it all here except "the sample was clear."

5967. Where do you get your note that on that day the sample was clear?—Here it is (*handing a paper to the learned counsel*); that is the rough note that I took in black lead pencil, then I wrote it down in my book afterwards.

5968. (*Sir John Coode.*) Is that rough paper the note that you made at the time?—Yes, that one I made in black lead pencil, and then I wrote it down in ink in the book afterwards.

5969. *Mr. Lumley Smith.*) This note on the 17th of July is on a piece of paper on which I see is written in pencil "S.O." What does "S.O." stand for?—That is southern outfall.

5970. Then there is the word "clear"?—Yes.

5971. That is all the entry for the 17th, but you have a fuller entry in your book, "Went to southern "outfall and took a sample," and you give the time?—Yes.

5972. On this piece of paper you have not got the time?—No.

5973. Where do you get your entry about the time?—I took the time from high water.

5974. And that was put in the next morning?—Yes.

(*Chairman.*) I think it would clear up the matter if we got a little more accurately the history of this paper.

5975. (*Mr. Lumley Smith, to the witness.*) In the boat you write on this piece of paper?—Yes.

5976. And I see your note of the 17th of July is "S. O. clear," that means "southern outfall, sample clear"?—Yes.

5977. When did you write in your book the entry which says that it was high water at 7.20?—After I had taken all the rough notes.

5978. (*Chairman.*) But how long after?—As soon as we had orders not to go any more to the outfalls I wrote it down in my book.

5979. The same day?—No, not the same day.

5980. How many days after?—We were doing it for five or six nights, I think.

5981. Then it was five or six nights after you first wrote on that paper that you put it into your book?—Yes.

5982. (*Mr. Lumley Smith.*) In the book you put "High water"?—Yes.

5983. Were they all taken at high water?—At the southern outfall they were.

5984. On the 17th at high water your sample is clear?—Yes.

5985. Then on the 18th at the southern outfall again it is again clear?—Yes.

5986. And that is at high water?—It is at high water.

5987. What did you do on the 19th?—On the 19th we went to the northern outfall and took a sample at 7.15; the sample was very thick, black almost.

5988. Do you know at what time it was high water on that day?—Yes, it was high water at 9.46 at London Bridge, that would be about 9.20 down there.

5989. You allow 26 minutes?—Yes.

5990. Then that would be before high water?—Yes, it would be two hours before high water.

5991. Were you able to see whether the sewage was escaping; is that a thing that you can actually see when you are in a boat?—Yes; you can see it coming out through the sluices.

5992. Can you do so at high water, or near high water?—Yes. This was a long time before high water; you could see it coming from the sluices, and it washed our boat away from the sluices.

5993. On this occasion, when you took your sample at 7.15, and you say it was thick, that was about two hours before high water?—Yes.

5994. Were you able to tell whether the sewage was escaping or not?—Oh, yes.

5995. On the 20th, your entry is "southern outfall, "sample clear"; is that at high water?—Yes.

5996. Your entry on the 21st is "northern outfall, "letting out," what does that mean?—I took a sample at 9.30.

5997. Your note here is "northern outfall, letting "out, took sample 9.30"; what do you mean by "letting out"?—Letting the sewage out.

5998. Then you made a note that the sewage was being let out at 9.30?—Yes.

5999. Do you know at what time it was high water on that day?—Yes, 12 o'clock at night, that would be about 11.35 there.

6000. The sewage was going out there at night about two hours before high water?—Yes.

6001. Your entry on the 22nd is, "Southern out-"fall, took sample at 12." Does that mean 12 o'clock?—Yes.

6002. "Clear"?—Yes.

6003. When was it high water on that day?—12.43 that night; that would be the next morning.

6004. "23rd N. O. letting out"; does that mean letting out the sewage?—Yes.

6005. "11;" does that mean 11 o'clock?—Yes.

6006. "Thick"?—It was very thick.

6007. When was it high water then?—At 1.43.

6008. There, again, the sewage was being let out on the flood?—Yes.

6009. "24th, at home;" "25th and 26th northern "outfall, took sample at 1.30 and 2.45." I suppose that entry was made after the second?—No, it was high water at 2.45; we took the sample at 1.30.

6010. "26th, northern outfall, took sample clear; "high water 3.47"?—Yes.

6011. And that is all, I think?—Yes, that was the last night.

6012. Is Lamerton here to-day?—He is here.

Cross-examined by Mr. Michael.

6013. What did you do with those samples which you had taken?—We gave them to Captain Fitzgerald.

6014. What were the samples taken in?—They were taken in bottles.

6015. How far from the surface of the water were they taken?—They were taken on the surface; we just put the bottle underneath the water.

6016. How large were the bottles?—About pint-and-a-half bottles, I should think.

6017. How many samples did you take altogether; did you take more than one at any particular time?—Only one at each time.

6018. How many times altogether?—There were six or seven of them, I am not sure which; there was

*Mr. T. Long.*

5 Dec. 1882.

one at each place. Each night that we went we took a sample, whether it was clear or thick.

6019. Was there a stopper to the bottle or a cork?—A cork.

6020. How long afterwards did you give it to Captain Fitzgerald?—The first night when we found it so thick we took it up to Captain Fitzgerald's house there and then; it was so thick and it stank so much.

6021. Did you give it to him?—Yes.

6022. How near was it to the outfalls that you took this matter that was thick and smelt badly?—We were not more than 30 or 40 feet away from the sluices.

6023. Do you know where the lip or apron is over which the sewage falls into the river?—At the northern outfall it comes out through arches.

6024. How near to them did you take the samples?—About 30 or 40 feet away.

6025. And how near were you at the southern outfall?—At the southern outfall we were right over the lip.

6026. So that you took the sewage as it came really out of the outfall?—Yes.

6027. You were not surprised to find it thick, I suppose?—No.

6028. It was absolutely the sewage that you took?—Yes.

6029. And the sewage had had hardly any opportunity to mix with the water?—Of course, when they let it out after high water it would have more chance of mixing with the water than if it were let out before.

6030. But you took it immediately as it came out at the outfall?—Yes; at the outfall.

6031. On all occasions?—Yes.

6032. For how many hours a day on an average are you on the river?—Ten hours a day on an average.

6033. Every day?—Yes.

6034. You do not seem to suffer very much?—Not always.

6035. Are there any other smells except the smell from the sewage that trouble you on the river?—The smells from the factories.

6036. Are they better or worse than the smell from the river?—Better.

6037. They never make you sick?—No.

6038. There are guano works, for instance?—I pass them every day, but you do not feel any ill effects from them.

6039. Does the smell from the river always make you feel sick?—In hot weather.

6040. And at 4 o'clock in the morning?—Yes.

6041. How many times can you recall in the whole of your life when you have felt sick?—I should say eight or nine times.

6042. And how many years have you been 10 hours a day on the river?—I have been in the Conservators' employment three years and six months.

6043. Before that what did you do?—I was serving my time on the water.

6044. You were on the river then?—Yes.

6045. What were you doing before when you were on the river?—Lightering.

6046. In barges?—Yes.

6047. Do they sometimes bring rather offensive stuff down the river?—Manure.

6048. Did that ever make you sick?—Never.

6049. You could be in the barge then with the manure for many hours and never be sick?—Yes, you could be in the barge with the manure and you would not smell it so much as if you were out of the barge, away from it.

6050. Then you have never experienced anything disagreeable from being with the manure in a barge?—No, not the least.

6051. It escaped away from you?—Yes.

6052. And none of these bad smells have ever affected you at all?—No.

6053. Merely the river?—Only the river, that is all I can put it down to.

Re-examined by Mr. Lumley Smith.

6054. My learned friend has asked you about your having taken these samples at the very outfall, if the sluices were shut down and no sewage was escaping, and it was high water or within a couple of hours of high water, you would get river water would you not?—Yes.

6055. By getting thick water you could see that the sewage was escaping?—Yes, and it pushed the boat away from the sluices.

Examined by the Commission.

6056. (*Chairman.*) But were not the sluices covered with water?—No, they were not covered, because the first time we went down the foreman of the outfall came out on the top of the sluices to speak to us.

6057. I was under the impression that the sluices were covered with water?—Not at the northern outfall.

6058. (*Sir John Coode.*) In answer to a question put by myself, a witness told us that these sluices were covered at two hours flood, you say they are not?—No, they are not.

(*Mr. Michael.*) This witness absolutely took the sewage out of the outfalls into his boat.

(*Mr. Lumley Smith.*) At a time when it ought not to have been discharged.

(*Mr. Michael.*) That is a matter which we will discuss afterwards.

(*Witness.*) The foreman belonging to the northern outfall came down on the top of the sluices on the night when we took it out and spoke to us in the boat.

6059. (*Chairman.*) And at that time you could see the sewage falling into the river?—Yes, coming into the river through the arches.

6060. It was actually falling into the water?—It runs into the water, there is no fall, it is all on a level where the bottom of the arches is. The arches come down underneath the brickwork, and the foreman came down on the top of the arches to speak to us.

6061. (*Sir John Coode.*) And you say that that was within two hours of high water?—It was quite two hours before high water.

6062. (*Chairman.*) And the arch was not covered then?—It was not covered then.

6063. (*Dr. Stevenson.*) At what time of the tide is the arch completely covered?—At three parts flood the arches would be covered.

The witness withdrew.

Mr. George Lamerton called in; and examined by Mr. Lumley Smith.

*Mr. G. Lamerton.*

6064. I believe you are a waterman on board the "Conservator"?—Yes.

6065. And, I believe, by direction of Captain Fitzgerald you went with Long to the outfalls to take some samples?—I did.

6066. Did you make notes of the times at which you went or of the samples which you took?—Yes.

6067. Will you give me your notes. (*The witness handed his notes to the learned counsel.*)

6068. (*Chairman.*) Did you and Long make your notes together?—Yes.

6069. (*Mr. Lumley Smith.*) You only took one sample between you?—That is all.

(*Mr. Michael.*) If he says it is the same note and the same sample I will not trouble him.

6070. (*Mr. Lumley Smith, to the witness.*) Do you remember being there on the 19th when the sewers were discharging when you took your sample?—Yes.

6071. Were you able to see that the sewage was coming out?—Yes; the man stood upon the top of the archway at the time, and the sluices were open, and I could see it running out. It washed the boat away.

6072. The arches at Barking at high tide are quite covered, are they not?—Yes.

6073. Are you able to tell how soon they are covered when the tide flows?—I should say at about half flood.

(*Mr. Michael.*) I think this witness is very nearly correct. I would not pledge myself to a few minutes, but I believe in about 2½ hours the arches would be covered; and that would be, as he says, about half flood.

*Mr. G. Lamerton.*

5 Dec. 1882.

Cross-examined by Mr. Michael.

6074. At the time that you took the sample the arches were not covered?—No.

6075. How far were they covered; how much could you see of the arches; could you see the crown of the arches?—Yes, half way down the arches.

6076. How long have you been on the river?—I have been at work on the river now for 17 years.

6077. How many hours a day do you live on the river?—Sometimes it is from 6 or 8 o'clock in the morning till 6 or 7 o'clock at night; sometimes all night.

6078. How long have you been on the river spending the whole of your time on the river?—About 12 years.

6079. What aged man are you?—I am 28.

6080. How many days on an average in a year are you laid up and unable to work?—I have not been laid up through it, but I have been very queer with the smell of the water.

6081. Are there any other smells on the river besides the smell from the water?—There is a factory down below.

6082. One?—There is one factory, I know, that smells at times.

6083. Is that a pleasant smell?—Not at all.

6084. Does that make you sick at all?—No, it does not make me sick, but it is a smell that you could not stand long.

The witness withdrew.

Adjourned to to-morrow at half-past 12 o'clock.

# ELEVENTH DAY.

## Wednesday, 6th December 1882.

PRESENT:

Sir P. BENSON MAXWELL in the Chair.

Sir John Coode, Mem. Inst. C.E.
Colonel C. B. Ewart, C.B., R.E.
Professor A. W. Williamson, F.R.S.

François de Chaumont, Esq., M.D., F.R.S.
Thomas Stevenson, Esq., M.D.
James Abernethy, Esq., F.R.S.E., Mem. Inst. C.E.

William Pole, Esq., F.R.S., *Secretary.*

Mr. William Turnidge called in; examined by Mr. Lumley Smith.

6085. You are a waterman on the "Conservator" steamer, I believe?—Yes.

6086. How long have you been one of the crew of the "Conservator"?—Going on for four years.

6087. Does the "Conservator" cruize up and down?—Yes.

6088. What is its ordinary duty?—Its duty is to see that the navigation of the river is kept clear.

6089. Are you on board night and day?—At times I am on board at nights.

6090. Is that when you have the night watches?—Yes.

6091. Is the steamer at moorings at night?—Yes, at night.

6092. Are they at any regular fixed spot?—Yes.

6093. Where is that?—At Charlton.

6094. Have you ever found the river offensive when you have been on board the "Conservator"?—Very much indeed at times.

6095. Have you ever found it interfere with your comfort or with your health?—Yes.

6096. In what way?—I have felt very sick indeed at times.

6097. Did that extend to your being actually sick, or were you merely sickish?—I have never brought anything up at any time, but I have felt very bad indeed, and on one occasion I was obliged to give over altogether, I was absent from work.

6098. Do you remember when that occasion was when you had to give over?—On the 26th of July 1880.

6099. To what do you attribute your illness then?—To the sewage water.

6100. You had not been drinking it, I suppose?—No.

6101. My learned friend, Mr. Bidder, suggests to me that I should ask you what you had been drinking. Was there anything, so far as you know, that could account for your illness, except this unpleasant smell from the river?—No, nothing whatever.

6102. Do you generally have good health?—Very good indeed.

6103. When did you find the river worst?—In 1880 I think it was much worse than at any other time.

*Mr. W. Turnidge.*

6th Dec. 1882.

Cross-examined by Mr. Michael.

*Mr. W. Turnidge.*

6 Dec. 1882.

6104. In 1880 the weather was very hot, and very dry, was it not?—Very warm at times.

6105. And it was in July of that year that you noticed that it was much worse than at any other time?—Yes.

6106. What were you doing at the time when you say you were obliged to leave your duty?—I was on watch the night previous, and we were obliged to get under weigh from our moorings at 3 o'clock in the morning to go to Greenwich. That was on the 26th, and that was when the sickness came over me.

6107. At what o'clock was it?—At 3 in the morning.

6108. How many hours do you usually spend on an average on the river every day?—From 10 hours and upwards.

6109. How old are you?—32 years.

6110. How long have you been on the river?—Going on for four years.

6111. But before that time where were you?—I was a fisherman.

6112. Did you fish in the river Thames?—At times, and at times I have been away to sea.

6113. You think that you were ill on this occasion on account of the smell from the river?—Yes.

6114. Do you think it was from the river itself?—Yes.

6115. Do you smell anything on the banks of the river?—No, I have not noticed anything.

6116. You do not smell anything from the works on the banks of the river?—There are a few smells, but nothing that affects me.

6117. Is the smell that you complain of in the water more powerful than the smell from the factories on the banks of the river?—Yes.

6118. And that is the thing which made you sick on this occasion at 3 o'clock in the morning?—Yes; I was ill throughout the day; I was unable to do any work.

6119. But that is the only time when you have been obliged to leave your work?—Yes.

6120. Where were your moorings on the day when you left at 3 o'clock and went up to Greenwich?—At Charlton. We left our moorings at Charlton.

Examined by the Commission.

6120*a*. (*Chairman.*) You only left your work once; did you ever feel sick except that once?—Yes, on several occasions.

6121. More than three times altogether?—At various times we have felt sick in the course of the warm weather. We have complained about it amongst ourselves on several occasions.

6122. But how often have you felt this inconvenience which you speak of?—I cannot say how many times, because I never made a note to that effect.

6123. But am I near the mark when I say three times?—A great many more times than that.

6124. (*Colonel Ewart.*) Had you to go to a medical man on account of it?—No, I was persuaded by Mr. Young to go to the hospital two or three times throughout the day, but I told him I thought I should feel better throughout the day.

6125. (*Sir John Coode.*) How long did you lie up?—I was absent from duty throughout that day, and for two or three days following I felt very queer, but I was able to do a little work on board the ship. My appetite fell very much indeed throughout the week.

The witness withdrew.

Mr. George Young called in; examined by Mr. Lumley Smith.

*Mr. G. Young.*

6126. You are, I believe, the master of the "Conservator"?—Yes.

6127. That is the steamer which takes the Conservancy officers about?—Yes.

6128. How long have you been the master of the "Conservator"?—Two years.

6129. How long have you been in the service of the Conservancy?—18 years.

6130. How long have you known the river?—For 30 years I have been constantly employed on it.

6131. I think, before you were in the service of the Conservancy you were a collier's pilot from Gravesend to London?—Yes.

6132. And you have known the river well for how many years?—Pretty well for 30 years.

6133. I will ask you first one or two general questions. Have you found any change in the character of the water since you have known the river?—Yes, very great changes indeed.

6134. You remember the outfalls being opened in 1864, do you not?—Yes, the northern one.

6135. And the other was opened a little later, I believe?—Yes.

6136. What was the character of the river at that time; in London the water was bad, I believe?—Yes, very bad indeed at that time.

6137. About how far down did the bad water go before the sewage was diverted to Barking and Crossness?—Down to about Bugsby and Woolwich. I have filled water for drinking purposes on board of the colliers in Gallions Reach at low water; in fact, that was a thing that was general.

6138. Was it general to drink the water?—To dip the water in Gallion's at low water for the ship's use.

6139. Then I suppose that was pretty good. What was it like up at Greenwich in those days?—It was not so clear at Greenwich, it was rather bad at Greenwich.

6140. Gallions is above the outfall, is it not?—Yes, it is in the same reach.

6141. What were Barking and Halfway Reaches like in those days?—They were comparatively clear, but of course the water is brackish down there; you would not drink that water.

6142. But when you come to Gallions Reach it has ceased to be brackish, and at low water you were able to drink it?—Yes.

6143. Since the outfalls have been opened have you noticed any change in the water in those reaches?—Yes.

6144. What do you find now?—Nothing but a mass of sewage.

6145. How far up do you find that the water is affected by the sewage?—It works its way, as far as I can see, up as far as Greenwich.

6146. Where is your ship moored as a rule?—At Charlton, off the upper part of the Royal Dockyard, Woolwich.

6147. You cruise about, I suppose, in the river at different places?—Between Greenhithe and Greenwich.

6148. Have you seen any change take place in the habits of the fishing vessels?—Yes.

(*Mr. Bidder.*) Is it necessary to go through that story about the fishing vessels again? We have had it five dozen times.

6149. (*Mr. Lumley-Smith to the witness.*) After the outfalls were opened did any change take place in the places where fish were caught?—Not for some four or five years.

6150. For some four or five years there was no change?—Not a great change.

6151. Where used the fish to be caught at that time?—I have seen them caught in Greenwich Bight, Bugsby, North Gallions, Long Reach, and so on.

6152. Does any fishing go on now in those reaches? No.

6153. I believe you have seen fish caught at Charlton lately, have you not?—Yes.

6154. How have they been caught?—By children on the banks, with their hands.

6155. Were they fish that seemed sick?—Yes, that is how they came to catch them. When they are brought down the river by these heavy rains, as soon as they touch this polluted water, of course the fish become sickly and weakened, and the children catch them with their hands alongshore.

6156. They survive the journey through London, and then they get so sickly at Charlton that they can be caught by hand?—Yes, I saw them catching them, and I saw the state the fish were in.

6157. I believe it is no part of your duty to take notes of the state of the river, is it?—It is not.

6158. But have you on occasions been instructed by Captain Fitzgerald to take notes?—During this past year I have; but I have made notes previously to that when the water was in such a state that it was not fit for any human being to live upon it.

6159. (*Sir John Coode.*) What was the particular part of the river where these fish were caught?—They were caught at Charlton beach, that is, between Siemens's electric factory and the ballast wharf.

6160. Have you seen the same sort of thing in any other part of the river?—No, only just there.

6161. Then your remark applies to that part of the river only?—Yes, in regard to the fish.

6162. (*Mr. Lumley-Smith.*) You mean in regard to catching the fish with their hands?—Yes.

6163. Is that where your ship was moored?—She was moored some quarter of a mile below that, but I was up there on duty, and I saw that.

6164. You have told us that you did take some notes in 1880, when it was very bad?—Yes, very bad indeed.

6165. You have your note, have you not, for the 26th of July 1880?—Yes (*producing a book*).

6166. (*Chairman.*) Is this book a log, or diary, or what?—It is the vessel's log.

6167. (*Mr. Lumley-Smith.*) Will you read your note on the 26th of July?—"Steam at 3 a.m. Pro- "ceeded from Charlton to blocks at Greenwich to "examine a portion of the vessel's bottom. While "there, the crew were employed in cleaning the "bottom, the sewage water having turned both "Jestey's composition, also the black paint, quite "brown."

6168. (*Mr. Bidder.*) What is Jestey's composition?—It is applied to prevent corrosion.

6169. (*Chairman.*) You keep the log yourself?—Yes.

6170. (*Mr. Lumley-Smith.*) Have you another paragraph in your entry?—Yes; "Steam from blocks "at Greenwich, arrived at moorings at Charlton at "4.30 p.m. Could not clean cabins, &c., on account "of the filthy sewage water at Charlton."

6171. What is Jestey's composition; is it a kind of paint?—It is a kind of paint to prevent corrosion.

6172. You say that the sewage water had turned this Jetsey's composition and the black paint brown?—Yes.

6173. Are you familiar with Jestey's composition and with black paint?—I have used it on this vessel only for two years.

6174. You say that it was the sewage that had turned it brown; what is your reason for saying that?—I imagine it by its turning its colour when it was quite clean only a day or two before; and on that morning more especially, when the water was, I think, about the worst I have ever seen, I noticed the vessel to be quite brown.

6175. It is not an affair of months; it is soon done. I understood you to say that it was done in a day or two?—The vessel was perfectly clean only a few days before.

6176. I see you make a note there that you could not clean the cabin on account of the filthy water; were you in the habit of using the river water for cleaning the cabin?—Yes.

6177. You have another entry on the 10th of September later on in the autumn; will you read as much of that as refers to the river?—Yes. "Crew "employed in stoning the deck, but could not finish "them until late in the evening on account of so "much sewage floating about." That is at Charlton.

6178. Will you explain why the sewage which was floating about should prevent your stoning the decks; what is the process of stoning the decks?—When they are scrubbed and they get a little rough, they rub a stone over them to brighten them up a bit.

6179. Why would the water outside prevent your doing that?—Because it prevents their sluicing them to wash the stuff off. The water was not fit for it. It was high water at about 4 o'clock on that day, and I had to wait until the tide had gone down past us and allow the sewage to get past the vessel, which made it, as I have remarked here, the evening before they could finish.

6180. Do I rightly understand you that at high water at Charlton, which is considerably above the outfalls, there was so much sewage floating about that you could not use the water for cleaning your decks?—Yes.

6181. You have another entry, I think, on the 22nd of September?—Yes.

6182. What is that entry?—"Crew employed in "various jobs about the vessel, the water being in "such a bad state of sewage that not until afternoon "could the vessel be washed down."

6183. That again is at Charlton?—It is.

6184. I believe that in July and August 1881 you made a few observations; was that by direction of Captain Fitzgerald?—Not in 1881.

6185. Then in 1881 you did it on your own account?—Yes.

6186. Will you give us the entry which you have on the 15th of July 1881?—"The river in such a bad "state of sewage, could not wash decks in forenoon."

6187. Where would that be?—At Charlton.

6188. Do you know at what time it was high tide that day?—4 o'clock in the afternoon.

6189. Then in the forenoon it would be rather low water, would it not?—Yes.

6190. What is your entry on the 18th of July?—"Anchored vessel off Greenhithe to wash decks, &c., "in consequence of the filthy state of the river at "Charlton through sewage."

6191. Would you in the ordinary course wash your decks at Charlton at your moorings?—Yes.

6192. On this occasion you went to Greenhithe?—Yes.

6193. Have you any entry of the time of the tide when this took place?—When we washed the decks it was about 1 o'clock in the day. The tide flowed at 6 o'clock at Charlton on that day, so that it would be low water time or the young flood at Greenhithe.

6194. (*Mr. Bidder.*) At what o'clock did you leave Charlton?—At 10 o'clock in the morning.

6195. (*Mr. Lumley-Smith.*) That would be on the ebb then?—We wash the decks on the young flood. On the ebb tide it would not be so well.

6196. But when you left Charlton, when the water was so dirty, what sort of tide would that be?—That would be about half ebb, a little better than half ebb.

6197. (*Mr. Bidder.*) And you got to Greenhithe at 1 o'clock?—I do not say what time we got there, because we called at several places, as we went along.

6198. (*Mr. Lumley-Smith.*) Will you read your entry on the 19th of July?—"River in a filthy state "of sewage, and not prudent to wet decks with it."

6199. That is at Charlton again?—Yes.

6200. Will you read your entry on the 20th?—"River in very bad state of sewage. Crew employed

*Mr. G. Young.*

6 Dec. 1882.

"conveying clean water from the shore to clean "cabins and vessel's outside with."

6201. That would also be at Charlton?—Yes.

6202. Then your men went ashore to get clean water?—Yes.

6203. What is your entry on the 21st of July?—"River in a filthy state of sewage, more especially "between Barking and Jenningtree Point."

6204. Have you an entry of the time of the tide on that occasion when it was so bad between Barking and Jenningtree Point?—I did not note that.

6205. What is your entry for the 22nd of July?—"Crew employed cleaning the vessel with water from "the shore, the river water not being fit for use."

6206. Where was that?—At Charlton.

6207. What is your entry on the 23rd of July?—"Crew employed conveying water from the shore to "clean vessel with. The river, although much clearer, "it is only on the surface, for I found the sewage to "be within 12 inches of the surface, and the stench "from the same being very bad."

6208. I think you have nothing more in that month, but you have an entry on the 2nd of August?—Yes, "Made vessel fast to a buoy in St. Clement's Reach "while washing decks, &c., through the river at "Charlton being in such a filthy state of sewage."

6209. Where is St. Clement's Reach?—Between Greenhithe and Grays.

6210. I think you have another entry on the 5th of September?—"River from Barking to Rainham in a "filthy state of sewage."

6211. Where is Rainham?—Rainham is considerably below Barking, the next town before you come to Erith.

6212. I think in 1882 you have some half dozen entries. There is one on the 17th of March 1882?—Yes. "Left Erith at 4.30 p.m. Between Erith "ballast wharf and Crossness the river in a filthy "state of sewage, the stench from same being very "bad."

6213. When was it high tide that day?—It was high tide at noon.

6214. At Erith?—At Charlton.

6215. And this would be about four hours after high tide?—Yes.

6216. That would be at a time when the outfalls were at work, I presume?—Yes, they would be running out on the ebb tide.

6217. Are you able to see the flow as it comes out; does it make any distinct track upon the river?—Yes, at times.

6218. I see that entry of yours speaks of the river; are you able to tell whether you were in the track of the sewage, or whether it pervaded the river generally?—It appeared to be right across the river there.

6219. Your next entry is on the 25th of March?—Yes. "In consequence of the river being in such a "filthy state of sewage, have not been able to clean "the vessel with the river water the whole of the "week."

6220. Where would that be?—At Charlton.

6221. What entry have you on the 6th of April?—"Crew employed conveying water from the shore for "the purpose of cleaning the vessel, owing to the "filthy state of the river water."

6222. Where would that be?—That is at Charlton.

6223. At what time of the tide?—That would be at low-water time, and on the early flood.

6224. You have an entry on the 30th of June, have you not?—Yes. "At 9 a.m. this morning the "river water at Charlton at about two hours flood "was in a stinking state of sewage, very offensive."

6225. That was a hot time, was it not?—Yes, that was this year.

6226. What is your entry on the 28th of July?—"The river in a very bad state of sewage from "about half way down Long Reach south shore to "Crossness."

6227. Have you any entry on the 2nd of October?—"At Charlton the river in a filthy state of sewage. "It appeared to be rising from the bottom of the "river, and caused very offensive smell. Unable to "clean vessel in consequence."

6228. What do you mean by "appearing to rise from the bottom of the river"; in what form does it come up?—It appeared as though it were fermenting, and rising up in small patches about the size round of an inkstand; and then it burst out, and spread round larger than a good size plate; and the smell from it became very bad. I can only describe it as though all the bed of the river was in a state of fermentation.

6229. In October it would not be such very hot weather?—No.

Cross-examined by Mr. Bidder.

6230. You have been for about two years master of the steamer, I understand?—Yes.

6231. Had you instructions to make notes in your log book about the river?—No.

6232. Are you quite sure, because we know that Captain Fitzgerald had instructions from the Conservators?—Yes, he may have had.

6233. But you are quite sure that you had none?—I am quite sure of that.

6234. I believe you have been constantly employed during the last two or three years in going about the river for the purpose of taking observations of the sewage, and of the mud, and for the purpose of taking samples, and so on?—No.

6235. For two years?—Occasionally, not so long ago as that. Last year I think was about the first of it.

6236. (*Chairman.*) You have been employed to take samples for about two years?—Hardly that. There is the first account of it, and that is in 1881.

6237. (*Mr. Bidder.*) You have been engaged in taking various gentlemen down to view the river for the purpose of the Sewage Inquiry, have you not?—Yes.

6238. It has been a matter of constant discussion on board the vessel, I suppose?—Yes.

6239. You have referred to 1880, 1881, and 1882; do you say that this year is as bad or not so bad as 1881?—Not so bad.

6240. What do you say comparing 1880 and 1881?—1880 was the worst.

6241. And 1881 next?—1881 was of course very bad during the warm weather.

6242. 1880 was the worst, 1881 not quite so bad, and this year again is not quite so bad as 1881?—Not quite so bad.

6243. Am I right in supposing that the entries which you have given us in 1880 are the 26th of July, the 10th of September, and the 22nd of September?—Yes.

6244. May I take it that those are the only entries in your diary tor 1880 which bear upon the sewage question?—Yes.

6245. In 1881 you have, I see, a very large number of entries, and you have constant entries that you could not wash the decks on account of the sewage?—Yes.

6246. There is only one entry in your book for 1880 of that kind, and that is the entry of the 22nd of September?—That is very likely.

(*Mr. Lumley Smith.*) The 10th is the same thing. He was stoning the decks.

6247. (*Mr. Bidder to the witness.*) You tell me that 1880 was the worst year, and July I believe was the worst and the hottest month of it?—I do not remember exactly about the weather.

6248. How do you account for it that throughout that last year until we come to September there is no

entry suggesting that the condition of the water prevented your washing the decks?—Probably not; probably the boat's being under repair or something of that kind made it unnecessary to do anything of the sort.

6249. I do not like to be on probabilities. Is it a fact that the boat was under repair?—I do not know without I look to my book. I do not exactly remember everything like that.

(*Mr. Lumley Smith.*) You will find on the 26th of July an entry that they were not able to clean the cabins.

6250. (*Mr. Bidder.*) Now let me understand about this entry of the 26th of July. The vessel, I see, proceeded to the blocks at Greenwich, and while there, the crew were employed in cleaning the bottom. I presume then that at low water she was left dry upon the blocks?—Yes.

6251. And the crew therefore would be upon the mud under the bottom of the vessel?—On the ground; we have no mud there, only beach.

6252. Is that the day when the last witness Turnidge said that he felt ill?—Yes.

6253. Was he working at cleaning the bottom of the boat?—He was too ill to work.

6254. I do not think he told us what he was doing, but as a matter of fact, he was employed in the manner you describe?—He was on board the vessel for that purpose, but he did no work.

6255. Are you quite sure that he was not at work when he complained of being ill?—I am quite sure that I did not allow him to work.

6256. What time in the day did you begin cleaning the vessel's bottom?—I suppose we began at about 5 o'clock in the morning. We went up to the blocks at about half past three in the morning, or something like that.

6257. I see you say it was high water at 4.30?—Yes.

6258. What is the character of this Jestey's composition?—I really cannot tell you any more than that it is a paint.

6259. Is it a preservative paint for the bottoms of ships?—Yes, it is a very good paint; it does not corrode like most paints.

6260. It is a composition intended to be applied to the bottoms of ships?—Yes.

6261. What is its colour when it is applied?—When it first goes on it is a kind of lilac colour, and then it changes to nearly copper colour when copper is thoroughly clean; and it maintains that colour to the last.

6262. I see your entry states that both that and the black paint had got brown?—Yes.

6263. Do you mean that that happened in a night, or that it had been getting gradually so?—In the course of a day or two.

6264. How long had this composition been on?—I could tell you by referring to that book, but I could not tell you otherwise (*after referring to the book*). That Jestey's composition had been put on, on the 2nd of July.

6265. How often do you renew that composition, as a rule?—About twice a year if necessary. If it does not get rubbed, it does not want doing so often as that; it only wants doing about once in ten months.

6266. Do you say that the black paint had also turned brown?—Yes.

6267. Is that oil paint on the ship's side?—Yes, vegetable black.

6268. What time in the day was it that Turnidge complained to you of being unwell on the 26th of July?—Shortly after I got on board the boat which would be between three and four o'clock in the morning.

6269. Of how many men does your crew consist?—Six all told.

6270. Were any of the others incapacitated for work that morning?—No, not on that morning. All felt a little queer as I did myself.

6271. But you had not complaints from any of the others of being incapacitated for work except from Turnidge?—Only from Turnidge.

6272. Will you indicate a little more definitely where these blocks at Greenwich at which you say you were lying.

(*Sir John Coode.*) Is it a gridiron laid down on the beach?—Yes, it is at the Union Wharf, or I may say half a mile below Greenwich Pier.

6273. (*Mr. Bidder.*) That fixes it. I am not going through all these entries of yours, but there are a great many entries in which you describe the condition of the river as being filthy on account of the sewage stopping your watering the decks and so on; on those occasions when you entered in your log that the condition of the river was so polluted, did you take any samples of the water?—No, it was no duty of mine to do so.

6274. But you had been engaged frequently in taking samples with a view of showing the pollution of the river, had you not?—No, not up to that time; 1880 is the year you have in question.

6275. I asked you with regard to the whole. I told you I was not going to ask you particularly as to each one?—I thought you were alluding to the morning when the vessel was on the blocks.

6276. I have a series of entries here, all of which describe the condition of the river as being filthy in different words. Some of them say that it prevented you from washing the decks and holystoning them and so on; and there are entries both in 1880 and 1881, and also in 1882, I think. On any of those occasions when you so describe the water as filthy, did you take a sample of the water?—No.

6277. Neither in 1880, nor in 1881, nor in 1882?—No.

6278. You have already told me that you had been engaged at that very time in taking samples at different part of the river in 1881 and 1882?—We have taken samples from time to time, but the principal of the samples were taken when I was away on leave of absence in August 1881. I was away on a holiday at that time. I never saw any of the samples.

6279. There is one occasion on the date of the 18th of July on which you have an entry about anchoring the vessel off Greenhithe, going to Greenhithe to wash the decks in consequence of the filthy state of the river at Charlton. I see from the whole of the entry in your book that you went to Greenhithe on the duties of your station?—Yes.

6280. So that it was not a special journey for that purpose?—No, but when we got there we saw a drop of clean water, which was quite a treat, so I thought I would wash the vessel down with it.

6981. You have had a strong feeling all through on this sewage question, have you not?—I think anyone would who is constantly on the river.

6282. How did you make the observation of the sewage being within 12 inches of the surface?—I noticed that the river on the surface looked very clear and I thought it might be fit for use, and yet the water smelt very strong. So I ordered a bucket to be put overboard to draw some to have a smell at it; and when they drew the bucket up, I found that the black water followed the bucket. So I ordered the bucket to be put a little lower down and drew it up, and I found it was one black mass.

6283. Where did this happen?—At Charlton again.

6284. Then you lowered the bucket to a greater depth, as I understand?—About a foot beneath the surface.

6285. You also said generally that the river in the lower reaches was nothing but a mass of sewage at times?—At times.

6286. I suppose I am to infer that you mean that it is principally composed of sewage?—Yes, principally.

6287. The major part of it?—Yes, apparently all on the surface all discoloured; and on that occasion when I speak of its being so bad on the south shore in Long Reach; it was worse than I had ever seen it down there.

Re-examined by Mr. LUMLEY SMITH.

*Mr. G. Young.*

6 Dec. 1882.

6288. How often in practice do you wash your decks?—Every morning if the water is fit.

6289. Do you do it at other times if the water is bad?—I have to wait all manner of times now. Sometimes I keep the crew there till some time in the evening if I think there is a chance of the water being clear at all.

Examined by the COMMISSION.

6290. (*Chairman.*) You say you have known the river for 30 years?—Yes.

6291. When you first knew it, I think you said the water was pretty clean up to Gallion's?—Yes, very clean.

6292. For some time before the outfalls were opened, had not the vessels ceased to take water at Gallion's?—Some had; but most of the Shields vessels, such as I worked for, supplied themselves with water there in Gallion's.

6293. As lately as 1863 or 1864?—As late as 1863 or 1864, and also at Duke's shore on the high water.

6294. Has not the river very much improved in character since the opening of the outfalls above those outfalls up to London Bridge?—I should think it has greatly, from Greenwich upwards.

6295. At first you say that the river was very clean so that all the ships were able to take the water; whereas afterwards it got bad, so that only some of the ships were able to take the water; had not the river got worse then as compared with the time when you first knew it up to the time of the opening of the outfalls?—The upper part of the river had become very bad only as late as 20 years ago.

6296. From Blackwall up to London Bridge?—Yes.

6297. The river has improved since then?—The upper part has greatly improved in consequence of the removal of the drains.

6298. What time was it when the upper part got very bad as compared with the time when you first knew it?—I can remember the upper part 20 years ago, and also in the summer of 18 years ago it was very bad. I was attacked with the cholera in consequence of it.

6,299. Then, as I understand you, the upper part of the river was clean at first, then it got very dirty, and then it got better again after the opening of the outfalls?—Yes, the upper part.

6,300. Since the opening of the outfalls from the outfalls up to London Bridge the river has been a good deal improved?—Yes, all above Greenwich the river is really much better than it used to be.

6,301. (*Colonel Ewart.*) Have you any regular medical attendant for the men employed in your ship?—No.

6302. Do they go to their own doctors?—To their own doctors.

6303. (*Mr. Abernethy.*) You have stated that your vessel is moored at Charlton, and you have stated also that you could not wash the vessels' decks down on account of the state of the water; has the river improved at Charlton since the opening of the outfalls?—It has become filthy.

6304. That is below Greenwich, is it not?—It is a matter of six miles below Greenwich.

6305. (*Mr. Balfour-Browne.*) But it is above the outfalls?—Yes, about two miles above the northern outfall.

6306. (*Mr. Abernethy.*) What is the state of the river at Blackwall as compared with what it used to be?—The state of the river is not so bad at Blackwall as at Charlton; it gradually diminishes in its filthy state as it comes upwards.

6307. What is the state of the river at Blackwall as compared with what it was previously to the opening of the outfalls?—It is decidedly worse.

(*Mr. Lumley Smith.*) My learned friend asked a question as to whether this ship was under repair. This witness's first entry seems to be on the 21st of June, and I find that the ship was under repair until the 29th of June when she went on the gridiron at Greenwich and remained on the gridiron till the 9th of July.

6308. (*Chairman to the witness.*) Is that so?—That is so; she was under repair until the 12th of July.

6309. (*Sir John Coode.*) The first entry that you gave us was the 26th of July when you said that the water was so dirty that you could not clean the cabin?—Yes.

6310. (*Mr. Lumley Smith.*) Have you any entry in your book about samples being taken?—That would be in 1881 or 1882 if so. It would not be in 1880, because I do not remember anything of the sort.

6311. (*Mr. Bidder.*) I will not keep you now if you will let us have access to your books, if necessary, afterwards?—Yes.

6312. Perhaps you will look over them at your leisure, and let me know in the course of half an hour?—I will.

The witness withdrew.

Mr. JOHN PHILLIPS called in; examined by Mr. BALFOUR-BROWNE.

*Mr. J. Phillips.*

6313. You live at Putney, do you not?—I do.

6314. And you were formerly chief surveyor to the Metropolitan Commissioners of Sewers?—I was.

6315. I think you were appointed to that office in the year 1847?—Yes, towards the end of the year.

6316. The Metropolitan Commissioners of Sewers had the entire management of the sewers of the Metropolis until the time when they were passed over by the Act of 1855 to the Metropolitan Board of Works?—Yes.

6317. I think you were at one time the chief surveyor to the Westminster Commission, were you not?—Yes, I was for two or three years. Previously to that, I was clerk of the works in the several districts for about two years.

6318. So that when you were appointed chief surveyor to the Metropolitan Commissioners of Sewers you had had considerable practical experience both as clerk of the works and as a surveyor?—That is so.

6319. Had you at that time made practical observations upon the sewers with a view to finding out the velocity at which sewage must flow in order to prevent deposit?—I was very anxious to ascertain that fact, finding that there was a large quantity of deposit in the sewers. I set to work making observations and experiments in the sewers, and the result of my observations and experiments was that the sewage must flow with a velocity of not less than $2\frac{1}{2}$ feet per second, or 150 feet per minute, in order to prevent the fœcal and other matters in suspension from depositing.

6320. In what sewers did you experiment?—In the Westminster sewers.

6321. Did your observations extend both to large sewers and to small branch sewers?—I found that whether the quantity of sewage was small, as in a branch sewer, or large as in a main sewer, the flow must be at the same rate of velocity of $2\frac{1}{2}$ feet per second so as to maintain sufficient force and energy in the stream to prevent the sewage matters from depositing.

6322. Are there in the Metropolis many sewers in

which the sewage does not flow at the rate which you have indicated?—There are hundreds of miles of sewers of this kind now in the Metropolis. These are called "deposit sewers," from the fact that the sewage does not flow at the rate of velocity which I have stated.

6323. Is that name "deposit sewer" used in reference to those sewers?—Yes.

6324. How are those sewers constructed; what is the shape of the bottom of them?—They have very nearly flat bottoms, wide flat bottoms with upright sides and arched top. In consequence of that shape the sewage spreads over a large surface and has no proper power and velocity to raise and carry away the fœcal and other matters.

6325. Of course the more you shaped it like a V, the more scour you would have?—The more you concentrate the flow in a narrow bottom of a V shape, the greater velocity you get to remove the sewage matters.

6326. And the more you flatten it out, the less velocity you get and the less scour?—Quite so.

6327. When you were chief surveyor to the Metropolitan Commissioners of Sewers, where did the main sewers of the Metropolis discharge?—Into the Thames.

6328. And where were their outlets; were they above or below the level of low water?—They were considerably above the level of low water.

6329. Do you remember the removal of old London Bridge in 1834?—I do. I saw it pulled down.

6330. Before old London Bridge was removed, what effect had it upon the water above the bridge?—In consequence of the large number of the piers of the bridge they acted like a dam across the river. In consequence of that the low water level above the bridge was four or five feet higher than it was below the bridge.

6331. When the bridge was removed, was the level of the water at low-water mark reduced in this part of the Thames above the bridge?—It went down to the lower level, which enabled the flat marsh districts of Lambeth and Battersea on the south side of the Thames, and of Westminster and Pimlico on the north side, to be drained four or five feet lower than they had ever been drained before.

6332. Under those circumstances, the water above the bridge being lower at low water, was there a much greater exposure of river bank than formerly?—There was a great deal more.

6333. In consequence of the exposure of a larger amount of river bank, or mud, was the sewage in this part of the Thames above bridge exposed upon the mud?—It was; it used to spread all over the banks and cause a deposit of sewage mud. For instance, between Westminster Bridge and Northumberland Street, Strand, where two or three main sewers discharged into the river, the deposit of sewage mud was not only large, but it went on increasing until the surface became covered with myriads of small red worms. The same was to be seen at other places near the outlets of the sewers.

6334. Do you remember anything that the Commissioners did with a view of preventing that?—Yes, we formed wood channels from the outlets of the sewers down to low water mark.

6335. (*Sir John Coode.*) Wooden trunks, I suppose?—Yes.

6336. (*Mr. Balfour Browne.*) With a view of carrying the sewage down from the sewers to low-water mark?—So as so prevent it from spreading over the river banks.

6337. Did that expedient have the desired effect?—Very little indeed.

6338. Was it brought back on the flood water?—The flood tides returning carried the sewage over the banks, and they were as bad as they were before.

6339. I believe that in the year 1846 there was a Mr. George Hawkins who was a coadjutor of yours?—Yes.

6340. And he and yourself made certain calculations with regard to the quantity of sewage flowing into the Thames?—Yes, he and I together made gaugings at the outlets of all the main sewers discharging into the Thames from the Westminster district; and after making our gaugings we made calculations from them of the quantity of sewage discharged into the Thames.

6341. Do you remember the result of those calculations?—Yes, the result was that the quantity of sewage discharging from the Westminster district per day of 24 hours was 1,798,094 cubic feet.

6342. Did you take any means of ascertaining at the same time how much water was being supplied by the water companies to the district from which that sewage flowed?—We ascertained the quantity of water supplied to the houses by the different water companies, and as far as we could make out, the quantity of sewage discharging into the Thames, was about equal to the quantity of water supplied to the houses by the water companies.

6343. At that time were the houses in that district that you are speaking of supplied with cesspools?—Yes, there was at that period one and sometimes two or three or more cesspools to almost every house in the Metropolis.

6344. Were those cesspools connected with the sewers in any way?—There was an overflow drain from them into the sewers in front of the houses.

6345. Do you remember when you began to abolish the cesspools?—I think it was in 1848. In the densely inhabited parts of the Metropolis, under the jurisdiction of the Commissioners, we emptied and filled up the cesspools, substituted pan waterclosets for them, and laid stoneware pipe drains from these into the sewers.

6346. Did you at that time calculate the amount of matter that might be collected in cesspools within your district?—I calculated, from data which I collected, that the capacity of the whole of the cesspools in the Metropolis on the north side of the river was equal to a canal 20 feet wide, about 5 feet deep, and 10 miles long extending right through London from Hammersmith to Bow.

6347. And these cesspools, or this hypothetical canal was full of fœcal matter?—Yes.

6348. And decomposing in the midst of the population surrounding it?—Yes.

6349. And in the process of decomposition emitting all sorts of gases of course amongst the people?—Yes, quite so.

6350. Was all that matter, which you have been describing, pumped out and discharged into the sewers?—Yes, it was, and washed through the sewers into the river.

6351. And so it found its way into the river Thames?—Yes.

6352. Just before the cesspools had been cleared out in the way you have described, is it a fact that there had been a serious epidemic of cholera in London?—There had been cholera very severely.

6353. And the Commissioners of Sewers at any rate adopted the system of turning all the sewage into the Thames rather than allowing it to decompose in the cesspools?—Yes. Of two evils it was thought to be the least to put what was in the cesspools and in the sewers into the Thames, rather than allow it to remain and so go on decomposing in them amidst the population.

(*Chairman.*) That outbreak of cholera of the year 1849 is a matter of historical notoriety.

6354. (*Mr. Balfour Browne to the witness.*) In consequence of this action of the Metropolitan Commissioners of Sewers, did the river become much fouler than it had hitherto been?—Very much so.

6355–6. And I believe that in consequence of the foul state of the river there was such an outcry, that it occurred to you, amongst other persons, to see whether some means could not be adopted for getting rid of the sewage altogether from the river?—Yes, it led me to consider the question of the formation of a system of outfall sewers not only for the Metropolis, but for

*Mr. J. Phillips.*

6 Dec. 1882.

the towns in the valley of the Thames right up to Windsor, as a substitute for the river.

(*Chairman.*) Do you not think that we are going very far in asking the ideas of this gentleman in 1849? I do not see what the drift of the examination is.

(*Mr. Balfour Browne.*) I think it was out of these ideas that the main drainage system of the Metropolitan Board ultimately arose.

(*Chairman.*) That may be very interesting and very honourable to the witness, but how does it affect this inquiry?

(*Mr. Lumley Smith.*) It is leading up to some experiments which he made.

(*Chairman.*) Then let us come to the experiments at once.

6357. (*Mr. Balfour Browne.*) It was in consequence of these ideas that he made certain tidal experiments which were ultimately utilized. (*To the witness.*) In 1849 was Mr. Frank Forster appointed engineer to the metropolitan commissioners?—He was.

6358. And I believe he was directed to design plans for the disposal of the sewage by means of outfalls, in the way you have been speaking of?—Yes.

6359. In the year 1850 he laid before the Commissioners a scheme for the interception of the sewage from the south side of the Thames, did he not?—He did.

6360. The works as designed by Mr. Forster, I think, were not commenced until the whole of the sewers were passed over to the Metropolitan Board.

(*Mr. Bidder.*) Does my learned friend suggest that the works were afterwards carried out? I have never heard that Mr. Forster's works were carried out.

(*Chairman.*) Whether Mr. Forster's scheme was carried out or not, is a very long way from this inquiry.

6361. (*Mr. Balfour Browne to the witness.*) Mr. Forster's scheme was to intercept the whole of the drainage on the south side of the Thames, and carry it into the Thames?—Yes, at some miles down the river from the Metropolis.

6362. Before that scheme was designed, had any tidal observations been made upon the river at all?—None whatever.

6363. I think in 1850 Mr. Forster prepared a similar scheme for intercepting all the drainage on the north side and carrying it into the Thames?—He did.

6364. Before that date had any tidal observations been made upon the river at all?—None.

(*Chairman.*) This witness cannot tell us about Mr. Forster's plans.

6365. (*Mr. Balfour Browne.*) Before these plans were designed, to your knowledge there were no observations with regard to the tide at all?—None, as regards the distances to which the tides would carry the sewage down and up the river from the points and periods of its discharge into the river.

6366. In May 1851, I think after the sites of the outfalls had been determined upon, you and a Mr. William Betts, your assistant, were directed to make tidal observations by Mr. Forster.

6367. (*Chairman.*) This is leading the witness into a matter that seems quite irrelevant. If the witness made any experiments which seem to you to be in any way material to our present inquiry, let us come to those experiments. (*To the witness.*) Did you make any experiments?—I did.

6368. In pursuance of certain orders which you received from Mr. Frank Forster the engineer, to the Metropolitan Commissioners of Sewers?—Yes, I made some tidal observations.

6369. In what year was it that you first made those experiments?—In 1851.

6370. (*Mr. Balfour Browne.*) Was that after the site of the outfalls had been fixed?—Yes.

6371. (*Chairman.*) Do you mean the Crossness and Barking outfalls?—The Barking Creek outfall.

6372. What did the experiments consist of?—We made tidal observations in the river by means of a float.

6373. On what day?—They extended over various days. Our report of the experiments is as follows:—

"Northern Drainage.

"Experiments on ebb and flow of tide in the River Thames.

"7, Hatton Garden,

"Dear Sir, 8th July 1851.

"In accordance with your instructions received on the 31st day of May, we have made a series of experiments to ascertain to what distances the sewage matter proposed to be emptied into the Thames at Barking Creek would reach at different times of the tide, and beg herewith to hand you the accompanying tables showing the various results of these experiments. The float used was of wood (6 feet long, 15 inches square at the bottom and 6 inches square at the top, and on the top of that was a flat piece of wood 15 inches square. There was a hole in the top of the float and there were perforations towards the bottom: and, in order to get the float to stand upright, we put some pebbles in to ballast it) and it was always kept in the strength of the tideway by being carefully shifted whenever it had a tendency to get into the slacks or eddies.

"The first experiment we commenced at high-water opposite Barking Creek, and the float drove down with the ebb by low-water 14 miles and returned with the flood 13¾ miles, being within quarter mile of the point where it was put in.

"2nd experiment. Float put in opposite Barking Creek one hour after high water, it drove down with the ebb by low water 13½ miles and came back with the flood 13¼ miles, being within quarter mile of the place where it was put in.

"3rd experiment. Float put in opposite Barking Creek two hours after high water, it drove down with the ebb by low water 10 miles, the wind blew so high that there could be no truth in the driving of the float, so discontinued.

"4th experiment. Float put in opposite Barking Creek at high water, it drove down with the ebb by low water 13¼ miles, and returned with the flood 10¼ miles.

"5th experiment. Float put in opposite Barking Creek one hour after high water, it drove down with the ebb by low water 11 miles and returned with the flood 10¼ miles.

"6th experiment. Float put in opposite Barking Creek two hours after high water, it drove down with the ebb by low water 10¼ miles and returned with the flood 13¼ miles, being 3 miles above Barking Creek.

"7th experiment. Float put in two hours after high water opposite Barking Creek, it drove down with the ebb by low water 11¾ miles and returned with the flood 13¼, being 2 miles above Barking Creek.

"8th experiment. Float put in two hours after high water opposite Barking Creek, it drove down with the ebb to low water 10½ miles and returned with the flood 13½ miles, being 3 miles above Barking Creek.

"9th experiment. Float put over one hour after high water opposite Barking Creek, it drove down with the ebb by low water 14¼ miles and returned with the flood 14 miles.

"10th experiment. Float put in at high water opposite Barking Creek, it drove down with the ebb by low water 15 miles and returned with the flood 13½ miles.

"11th experiment. Float put in three hours after high water, it drove down with the ebb by low water 7¼ miles, the wind then came on to blow so strong that we were obliged to desist, but supposing the flood to act the same as it did in the last experiment, the float would have gone up 13 or 14 miles, being about Greenwich.

"12th experiment. Float put in two hours after high water opposite Creek's mouth, it drove down with the ebb by low water 8 miles, and returned with the flood 9¾, being 1¾ miles above Barking Creek. This experiment was continued without stopping for

10 whole tides, by which time the float reached at low water a point 27 miles from Barking Creek, and at high water 19 miles, being 4 miles below Gravesend. This experiment was commenced between the spring and neap tides, and, as the tides took off, the float gradually worked lower and lower down the river at each high water time, and had the experiment been continued on to the next springs we are of opinion that the float would have gradually worked its way up the river at each high water time, until at high water or the best springs it would have been only 15 miles from Barking Creek or about Gravesend.

"13th experiment. Float put in two hours after high water opposite Barking Creek, it drove down with the ebb by low water 8 miles and returned with the flood 11¼ miles, being 3¼ miles above Barking Creek. This experiment was then continued tide after tide for eight tides, when we found the float arrived at low water 7 miles below Barking Creek, and at high water 7½ miles above, being opposite Deptford Dockyard. This was the highest spring tide. We then continued on again for five more tides, and found the float then at low water 10 miles below Barking Creek, and at high water 5 miles above it, showing as in the continuous experiment, No. 12, that as the tides take off, the ebbs become more powerful than the floods, and consequently each tide carries the float further down the river. This experiment was commenced as the springs began to increase, and shows up to the eighth tide that the floods during the springs were more powerful than the ebbs, after which, as just before observed, the ebbs gradually obtain the mastery. From the above experiments we would beg to observe that in five trials, the float each time being put in opposite Barking Creek two hours after high water, it has always returned above the point at which it was put in on an average for a distance of 2½ miles. We could venture to suggest that before giving any decided opinion as to the deposit range of sewage proposed to be put into the River Thames at Barking Creek, another series of experiments should be made, one commencing at the lowest neap tides, and continuing on through the springs to the lowest neaps again; and the other beginning at the highest springs, continuing on through the neap to the next highest springs. These experiments should not be delayed, as the nights now are at their shortest and it is extremely difficult and dangerous to watch or tend the float in the dark, especially when (as often happens) there are many large steamers and other vessels going up and down the river; and also that we might take advantage of this fine weather, as no dependence can be placed on the accuracy of the floats driving when there is much wind.

"We are, dear Sir, your obedient servants,
"William Betts, jr.
"John Phillips."

6374. (*Chairman.*) Could you fix the time of the year when these experiments were made?—In the month of June, just before we made the report.

6375. (*Mr. Balfour Browne.*) The instructions were given on the 31st of May. (*To the Witness.*) Did you follow the float yourself in a boat?—Yes.

6376. So that all these experiments were made by yourself, and this is the result of your own observation?—Quite so. No one was engaged in making these experiments but myself and my assistant William Betts.

6377. You recommend in that report that another series of experiments should be made?—Yes.

6378. Were you instructed to make them?—Yes.

6379. And did you make a second report dated the 11th of September, 1851?—Yes, I will read it—

"*Northern Drainage.*

"7, Hatton Garden,
"Dear Sir, 11th September, 1851.

"Herewith we beg to hand you the result of the two last continuous experiments made to ascertain the relative strength of the ebb and flow of the tide in the river Thames. The first you will perceive was commenced two hours after high water on the top of the springs, and the second two hours after high water at the lowest neap tides, the point of commencement being opposite Barking Creek, as in the experiments previously made.

"The first was commenced on the 15th July two hours after high water, the float being put in opposite Barking Creek; and by low water it drove down to a point 11½ miles below the starting point, and returned with the flood to a point one mile above Barking Creek at high water. The next ebb the float drove down to a point 11¾ miles below Barking Creek, being a distance of 12¾ miles for the whole driving of one tide, and the next flood the float drove up to Barking Creek by high water; and so we proceeded tide after tide with little variation. As the floods became weaker the ebbs were (in proportion) stronger, and as will be seen by the accompanying sheet the float worked lower down the river by each succeeding high water until the 24th of July when it reached a point at high water 13 miles below Barking Creek, after which, as the floods again became each day stronger, every tide worked the float higher up the river, until on the 29th July it had reached a point at high water only five miles below the Barking Creek, thus giving as the excess of strength in the ebbs over the floods for 15 days' driving, only five miles.

"The next experiment was commenced two hours after high water at Barking Creek on the 6th August, the tides being then the lowest neaps, and the float gradually worked up the river each succeeding high water until the 12th August, being the highest spring, it reached a point 6¼ miles above the Barking Creek at high water; and from that time until the 20th it gradually worked down the river, tide by tide, when it reached at high water a point 9½ miles below Barking Creek. As in the former experiments, there are some seeming anomalies, yet it proves very satisfactorily that all that had been done before was in the main correct.

"The deduction we draw from these experiments and to which we most respectfully beg to draw your attention is the fact that if the sewage be not put into the Thames at Barking Creek at some period earlier than two hours after high water each tide, there will always be the certainty of its going up the river as far as Greenwich; and should a long continuance of northerly winds happen just after the times of lowest neaps, there is every probability of its being driven up so far as Rotherhithe.

"We have made several experiments by putting the float over at high water, and the result of these experiments is that the sewage should be poured into the Thames at or as near after high water as possible, to effect which the bottom of the reservoir must be not more than 2 feet below average high-water mark, or 9 feet above Ordnance datum. This would give (allowing the invert of the sewer to be 1 foot above bottom of reservoir) a fall from the crossing the North Woolwich railway to the reservoir of 2 feet 6 inches per mile, a fall, considering the situation, ample for all practical purposes.

"The sewer, of course, would have to be made of greater capacity than when a uniform inclination of 4 feet per mile was proposed; and should you coincide with the view we take of this matter we will lay the gradient down on the main upper line as here proposed, viz.: from the reservoir to the crossing of the North Woolwich railway at the rate of 2 feet 6 inches per mile from the crossing of the North Woolwich railway to the crossing of the East and West India Docks and Birmingham Junction Railway at the rate of 2 feet per mile, and from that point to the junction of Ranelagh sewer, Uxbridge road, at the rate of 4 feet per mile.

"We are, dear Sir,
"Your obedient servants,
"John Phillips,
"William Betts, Jnr."

*Mr. J. Phillips.*

6 Dec. 1882.

6380. (*Mr. Balfour Browne.*) Do you know of any other trial experiments which were made with the exception of those which you have been speaking of to the Commission?—No, I do not; no other experiments of the kind were made.

Examined by the COMMISSION.

6381. (*Colonel Ewart.*) All your experiments were made in the summer time, were they not?—They were.

6382. Do you recollect whether it was a dry summer or a wet summer?—It was a dry summer and very fine weather.

6383. (*Prof. Williamson.*) You told us some time ago that a considerable quantity of solid matter is deposited in the sewers?—Yes.

6384. Of what nature is that solid matter, is it sand, earthy matter, or what is it?—It is partly silty matter, but chiefly soil matter.

6385. Do you mean night soil?—Yes, night soil and general house and street refuse matters, partly liquid and partly solid, which are thrown down and washed into the drains.

6386. Have you frequently had occasion to remove it from the sewers, and examine it and see what it is?—Frequently, and it was of the character that I have told you.

6387. When you said that a velocity of $2\frac{1}{2}$ feet per second in this liquid prevents any deposition, does that statement apply to the various kinds of solid matter, to the silt and also to what you call soil?—To the silty matter, the fœcal matter, and all kinds of organic matters that pass into the sewers, and form, with the liquids, the compound called sewage.

6388. Do they all require the same velocity to prevent the deposition, or do some require a greater velocity than others?—The ordinary sewage requires that velocity to prevent the matter held in suspension from depositing.

6389. (*Chairman.*) You say the ordinary sewage; is that a mixture of the two, the sandy matter and the fœcal matter, or the fœcal matter alone?—There is a very small quantity of silty matter as compared with the fœcal matter and the various other matters which I have referred to.

6390. But your observations as to the $2\frac{1}{2}$ feet per second relates to the composition of the fœcal and the sandy matter?—Yes. Of course it does not apply to pebbles or rubbish or anything of that nature.

6391. (*Professor Williamson.*) Did not your float often get aground?—We never suffered it to get aground. We always followed it, and whenever there was a tendency for it to run into the slacks or into the eddies the man who was following it (sometimes I should be in the boat with him myself) always laid hold of the float and towed it out into the strength of the stream.

6392. You put it where the stream was strongest?—Yes.

6393. So that it does not give the average velocity but the greatest velocity?—The greatest velocity. We always kept it as much as we could in the strength of the tide.

The witness withdrew.

Captain EDWARD BURSTAL, R.N., called in; examined by Mr. LUMLEY SMITH.

*Capt. E. Burstal, R.N.*

6394. I believe you are a captain in the Royal Navy?—Yes.

6395. And I believe you are the secretary to the Thames Conservancy Board?—I am.

6396. When did you first know the river Thames?—In the year 1832.

6397. Were you for some time after that employed under Captain Bullock, who made a survey of the river by order of the Admiralty?—I was.

6398. I think that the charts were on a large scale, 20 inches to the mile, and the depth of water shown on them was the ordinary low-water spring tide, 19 feet 9 inches, below Trinity high-water level?—That is the scale, and that is the depth to which they were reduced.

6399. In 1861 the Conservators directed a survey to be made of the river on the same scale as that of 1832, did they not?—They did.

6400. And you have compared those charts, have you not?—Yes, I compared the Admiralty charts of 1832 with the Conservancy charts of 1861.

6401. There are, I believe, one or two points of difference which you desire to point out. Halfway Reach is the reach before you come to Erith, the reach in which the Crossness outfall is situated?—Exactly.

6402. Do you find much difference between the depths in the fairway or midchannel of Halfway Reach?—No, there was very little difference. The Admiralty chart of 1832 and the Conservancy chart made from the survey of 1861 agreed very nearly indeed. There was scarcely any difference between these two charts, through what was well known as the Fairway Channel in Halfway Reach all the way down.

6403. You have the charts here, I believe?—I have.

6403*a*. There have been certain spits taken away, have there not?—Between 1832 and 1861 a great many hand-dredgers were at work under license from the Trinity House, and those hand-dredgers dredged away the spit at Leather Bottle Point or Halfway House Point, at the upper part of Halfway Reach, and they dredged away the sand spit off Jenningtree Point, which is at the lower end of Halfway Reach.

6404. Are they both on the same side of the river?—Both are on the south side of the river.

6405. Then those appear in the charts of 1832, but not in the charts of 1861?—They do not appear in the chart of 1861.

6406. Can you tell us what, if any, change that made in the current of the stream?—I cannot say positively what the change was, but all I can say is this: that having two long spits of sand removed from the point, the stream running either ebb or flood, the ebb tide against the Leather Bottle Spit, or the flood from Jenningtree Point Spit, would have a tendency, and a very material tendency, to conduct the stream more towards the middle, or south side, of the river than it would when those spits were tending to divert the stream towards the north side of the river.

6407. Would that be equally true of the flood and the ebb?—Yes.

6408. Besides those spits, have any banks been dredged away?—Yes, there were some banks removed, by whom I cannot say, but there were in 1832 some very long narrow ridges of gravel shoal on the northern side, the Dagenham Shoals, as they were called, having eight or nine feet of water over them, and they were removed to a great extent before 1861. They do not appear in the 1861 chart.

6409. That 1861 chart would be shortly before the outfalls were opened?—Some few years before the outfalls were opened.

6410. (*Mr. Michael.*) Three years before?—Yes.

6411. (*Mr. Lumley Smith.*) We have heard that there has been a great amount of dredging done at the Rand's Hill?—That is a shoal in the middle of the river about three-quarters of a mile below Erith.

6412. That has been done since 1861, I believe?—I think it began about 1861, but I am not quite sure.

6413. But it appears, I presume, in the 1861 chart?—It does. I know that the shoal was there in 1861.

6414. In Barking Reach, is there now any bank or shoal which does not appear in the chart of 1861?—There is a quantity of mud deposited on the south shore between Margaretness on the south side of the river and Leather Bottle Point on the south side.

(*Mr. Michael.*) That was one of the subjects of inquiry before the arbitrator.

6415. (*Mr. Lumley Smith.*) Does that quantity of mud amount to a bank?—Yes; and there is also a large quantity on the north side below False Point.

6416. First of all, with regard to the bank on the north side of Barking Reach, will you tell the Commission what that is?—That is a mudbank which has accumulated to a very great extent below the Powder Magazine, about three-quarters of a mile below Barking Creek.

6417. That has accumulated since when?—Since the sewage has been sent out into the river—since 1861.

6418. I do not think you gave me the dimensions?—I do not know them without measuring on the chart.

6419. It is a considerable bank, is it not?—Yes.

6420. Have you examined it at all to see the character of the stuff of which it is composed?—Yes, I have done that.

6421. What, in your opinion, is it composed of?—Very black mud, very deep and very slimy, and with not much sand or gravel in it.

6422. Have you compared it at all with the Thames mud at a distance from the outfalls?—It does not appear to me that that mud is at all like the mud that is found on the shore in this river, or any other river that I know, just outside the banks between high and low-water mark. It is not in any way of the same character.

6423. Are there any other characteristics of it at all that would lead you to an opinion as to it; does it smell in any way?—In warm weather it smells very badly; and in cold weather you may get the mud up from the bottom of the river almost opposite the outfall, and you cannot smell it. In cold weather I have got the mud up from the middle of the river opposite the sewer and in many other places, and you cannot detect any smell from it.

6424. Are you speaking now of the same places?—I am speaking of the shoal exactly opposite the outfalls and the mud in Erith Reach.

6425. But are you speaking of this same bank which smells badly at some times and not badly at others?—I must candidly confess that I have not been to all these banks at various times of the year; but I have been in the summer, in hot weather, when the mud has stunk very badly indeed; and I have been there in the winter to the same sort of bank, and I have not been able to detect any smell.

6426. Have you tested that bank in particular in the winter?—Not that bank in particular, but I have tested other banks close to it.

6427. Are you able to tell the Commission how the tide sets from the Barking outfall?—I remember it quite well, for I took the set of the stream last year. I put one float in at Barking Creek close outside of low-water mark, and it drifted with a very strong current all along that northern shore until it got to False Point; that is to say, the north shore of Barking Reach. There it gradually set off, that is to say, there was a bay to the eastward of False Point, and below False Point in that bay it was slack water. In that bay is the place where there is so much mud deposited. From thence it took a middle course and went down Halfway Reach about three parts across on the northern side and straight down the reach That was the direction of that current. Then there was another stream which I was very curious indeed to take, and at the same time I started a float 7 or 8 feet long, submerged its whole depth excepting about 9 inches, say. I put that float in 100 feet off Leather Bottle Point, quite close in on the south side. That float followed the southern shore right away down to within 350 or 400 feet of the wharf of the southern outfall buildings, and it went parallel with the southern shore all the way down the reach until it got half a mile below the outfalls. The velocity of the current was 2½ miles an hour. That was very curious, and I was much surprised when I saw it, but that is the fact, and it is plotted on the chart. The floats that were being put in on the other side in the main channel over against the Dagenham shoals at the same time were going at the rate of about 2¾ miles an hour; there was about a quarter or half a mile difference in the velocity of the current.

6428. Leather Bottle Point is just above the Crossness outfall, I think?—About half a mile or three quarters of a mile above the Crossness works.

6429. There is a bank, I think you have told us, on the south of Barking Reach?—Yes, between Leather Bottle Point and Margaretness.

6430. That has accumulated since when?—Since the outfalls have been at work.

6431. Do you make a distinction between 1861 and 1864?—No, I have not observed that, except that I compared it with the new chart of 1861 and showed that a bank had formed since the outfalls were opened on the south side.

6431*a*. (*Mr. Michael.*) Since 1861, you mean?—Yes, since 1861.

6432. (*Mr. Lumley Smith.*) What is the character of the composition of that lower bank?—That is a black muddy bank too.

6433. Of the same class as the other?—Very much so.

6433*a*. What slack water would there be, according to your view, in Barking Reach?—The slack water in Barking Reach would be on the south shore at the very place where that bank is; and if I may venture to make the remark, I consider that that bank is caused by the dirty muddy water stirred up by the paddle wheels and screws of steamers over that large shoal which formed off the southern outfall works, and brought up the river by the flood current; and when it comes round Leather Bottle Point and flows up Barking Reach it gets into the eddy, and there it is deposited.

6434. Whatever matter is in suspension, and wherever it came from, it would naturally deposit when it got into slack water?—Yes.

6435. Used that southern part of Barking Reach to be used by colliers?—Yes, always, as long as I can remember, for vessels that had to come up the river and wait until their cargoes were sold at the market; they would be brigs drawing 16 feet of water.

6436. And in Halfway Reach also?—I am speaking of Halfway Reach, not Barking Reach.

6437. Used there to be colliers, sections for brigs, there; I think that is the technical term?—It was a place set apart by the Corporation of London for vessels to lie at until their cargoes were sold.

(*Chairman.*) Is this going to the question of navigability?

6438. (*Mr. Lumley Smith.*) No, the question of the navigation has been disposed of; but in considering how far the river is suited for sewage discharge, it is necessary to know what the river consists of, and I believe contour sections have been taken. (*To the witness.*) What used those vessels to draw?—16 feet.

6439. And that is where you now find this bank?—Yes; now there is about seven or eight feet of water.

6440. Was that part of the fairway of the reach?—That was when I first knew the river, and for many years afterwards the fairway of the reach right down to the southward of mid-channel of Halfway Reach.

6441. How soon after the sewage works had got into full operation was the attention of the conservators drawn to the state of the river?—I am not quite sure, but I should think about 2½ or 3 years afterwards.

*Capt. E. Burstal, R.N.*

6 Dec. 1882.

6442. What course did the conservators take?—They ordered a survey to be made of the river, and that survey was made and the plans compared with the soundings of 1861.

6443. Was that survey reduced to writing?—Yes, it is on a chart. We have the chart in the room.

6444. Are you able to tell us the result of the survey?—Yes, the result of it was this: that a large mud bank had formed and was forming off the southern outfall, off the works on the southern side of Halfway Reach; and that mud bank occupied the place that the deep water channel used to be in. On that mud bank there were in the new survey 8 or 9 feet of water at low water spring tides, where, according to the survey of 1832, and the chart of 1861, there were depths of 15 to 16 feet.

6445. I will take you now to Erith Reach, that is rather below; comparing the chart of 1832 with the chart of 1861, did you find that there had been much dredging executed in Erith Reach?—A great deal. A large portion of it was done in the upper part of Erith Reach, that I just referred to, off Jenningtree Point. Another large portion was the middle ground, about halfway down the reach, nearly in mid-channel, which had only four feet of water over it at low water spring tides. There was another shoal off Cold Harbour Point, at the lower end of the reach, which extended a long way out, and that was also removed. So that in the chart of 1861 neither of those shoals appears.

6446. The water then had been deepened considerably in Erith Reach?—Yes; I should say that 13 or 14 feet of deepening had taken place in Erith Reach.

6447. Did you find that there was any alteration in the sectional area between 1832 and 1861?—I did not measure it exactly with that object in view, but I found that the shoals had been removed, and I found, on comparing the depths on the Admiralty chart of 1832 with the depths on our chart of 1861, that the soundings and the depths of water at Erith were actually deeper in 1861 than they were in 1832. That is shown plainly on the plans and sections that I have prepared.

6448. Then the water had deepened; would that be in front of the town?—Along the whole front of the town at Erith, from Church Hole down to where the Erith jetty is, Easton's and Anderson's works, the low water mark was closer to the shore in 1861 than it was in 1832.

6449. Then there had been no accumulation of mud at Erith at that time?—Not only was there no accumulation of mud at Erith at that time, but, if you examine the charts, putting the tracing of one date upon the tracing of another, you will there see by the different coloured figures that the water was actually deepened during that period off Erith.

6450. A survey was again made in 1879?—Yes.

6451. And you have the chart?—Yes.

6452. What change do you now find in Erith Bight?—I find, by comparing the depths in Erith Bight, by taking a chart of the same scale, and laying it on the two other charts, that a very large accumulation of mud has taken place in Erith all the way along the shore in 1879, to the depth of seven or eight or ten feet vertically.

6453. Along what distance of shore do you find this accumulation?—I should think half a mile or three quarters of a mile, all along Erith town.

6454. That would appear by the chart, I suppose?—Yes, the charts and sections will show it.

6455. Had the depth of water increased or decreased in 1879 as compared with 1861?—It had decreased.

6456. Where do you find that it has decreased?—All the way from Erith Church by the Corinthian Yacht Club Causeway the whole length of the town of Erith, I should think, down to the pier.

6457. You have sounded the mud yourself, have you not?—Yes, I have tried it with an iron pole.

6458. What depth do you find?—I have gone down nine feet of mud before it came to a hard bottom.

6459. What kind of mud is it?—Black, very nearly the same sort of mud as I described further up.

6460. I think that as late as October 1882, that is a couple of months ago, another survey was made of the river in that locality?—Yes, the sections are plotted on the same scale there to show what it is now in October 1882.

6461. I presume that somebody else will speak to those?—Yes, those who made that survey will speak to their accuracy, I saw them plotted. They show that there is still an accumulation going on.

6462. In 1879 did the conservators receive any petition from the inhabitants of Erith?—They did.

6463. What was that for?—The petition was that the Conservators would elongate the Causeway because so much mud had accumulated at the end of it.

6464. (*Chairman.*) Did you elongate the Causeway?—We did. The engineer made a report upon it.

6465. (*Mr. Lumley Smith.*) Mr. Leach your engineer, who is now dead, I believe reported, and you did elongate the Causeway?—He reported on his examination of the place and of the mud that was formed near the Causeway.

6466. You have seen it, I suppose?—Yes, I have.

6467. Do you know the amount of increase?—I think they lengthened it 150 feet; it was upwards of 100 feet, I know, and it was made a floating causeway kept down by chains.

6468. (*Chairman.*) I think we had one witness who said 120 feet?—I forget, but I should think it is 150 feet longer.

6469. Have you seen the warping buoy which is moored off the ballast wharf?—I have seen the chart of it.

6470. What does it appear at low water?—I believe there are only two or three feet of water there at low water now. There used to be 13 feet.

6471. (*Prof. Williamson.*) You say that you believe it; do you know it yourself?—Yes, at the warping buoy.

6472. (*Mr. Lumley Smith.*) The chart shows two or three feet?—Yes.

6473. Where do you get your depth at previous times?—At 19 feet 9 inches below Trinity high water. They use 20 feet in round numbers now, so that it is a little lower than it was in former days. We get it from the office chart. When they applied for the buoy there was a plan showing the depth of 13 feet.

6474. Have the Corinthian Yacht Club recently extended their causeway?—They have.

6475. Was that done by permission of the Conservators?—They asked permission, and it was given.

6476. What was the ground of that request?—Because the mud had accumulated so much that they could not get their boats in.

6477. Some questions have been asked as to whether the removal of Erith Rands Hill may have caused this deposit of mud at Erith Bight; have you an opinion upon that subject?—I have heard that such questions have been raised. I cannot imagine for one moment that the removal of a shoal which was in the middle of the river, about three quarters of a mile below Erith, could have any possible effect in causing a deposit there. I should think it would be exactly the other way.

6478. (*Mr. Bidder.*) It would be fair to direct Captain Burstal's attention to a shoal directly opposite Erith Bight. I do not know whether its name is Rands or not?—It is three-quarters of a mile below the town. I am speaking of Rand's Hill.

6479. The one meant to be suggested is a shoal exactly opposite that very bight?—I never knew of a shoal there. You must tell me what shoal you are alluding to.

6480. (*Mr. Lumley Smith.*) We have heard that the crown of Rand's Hill was removed by the Trinity House and that the dredgers afterwards removed a good deal more of it; would the removal of the Rand's Hill make any difference?—No.

(*Mr. Bidder.*) It is my mistake as to the name.

6481-2. (*Mr. Lumley Smith.*) Has the spit which is close up at Erith at Coldharbour Point been removed?—That was removed to a very considerable extent between 1832 and 1861. A great number of sand dredgers were licensed by the Trinity Board to remove that shoal. I cannot see myself in what way the removal of that shoal is to cause an accumulation at Erith.

6483. Would it be at all likely to cause slack water there?—I cannot see it. The ebb stream comes fairly down Erith Reach and runs down clear of that shoal and turns round the Point. But after that shoal at Coldharbour Point, that I have just given evidence about, was removed between 1832 and 1861, the water had actually deepened at Erith.

6484. Then as a matter of fact the greater part of this shoal had been removed before the outfalls were opened?—Yes, long before. It was not until after the outfalls were opened and the water was muddy that this deposit formed.

6485. I think in the year 1856 you caused some experiments with floats to be made for the purpose of observing the strength and the direction of the tides?—I made some experiments by order of the First Commissioner of Works.

6486. I believe those were made by direction of the Commissioners of the Admiralty?—Not by direction of the Commissioners of the Admiralty, but by permission of the Commissioners of the Admiralty asked by the First Commissioner of Works.

6487. That was Sir Benjamin Hall, I believe?—It was.

6488. Will you tell me how you came to be directed to make those experiments?—I was employed by permission of the Admiralty under the orders of Sir Benjamin Hall in 1856 for the purpose of examining this river from Putney all the way down to Woolwich, specially with reference to new Westminster bridge and its foundations.

6489. I believe Mr. Bazalgette had furnished you with the experiments made in 1851?—He did, with the experiments made by Mr. Frank Forster.

6490. Those are the experiments which Mr. Phillips spoke about to-day?—Yes.

6491. (*Mr. Bidder.*) Did you report to the Metropolitan Board of Works?—No, to Sir Benjamin Hall, the First Commissioner of Works.

(*Mr. Lumley Smith.*) The report is dated the 30th June 1856, and it is printed in the Report of the Metropolitan Board of Works for 1856. It is as follows:—

"Sir,

"In compliance with orders from my Lords Commissioners of the Admiralty that I should make observations in the tidal stream in the river Thames with reference to former observations made in 1851 at the instance of the Metropolitan Commissioners of Sewers; and further for your information having done so, I beg to lay before you the result of my experiments.

"Mr. Bazalgette (Engineer to the Metropolitan Commission of Sewers) having furnished me with the experiments made in the tidal stream in 1851, I have been enabled to compare my own observations with them, and can bear testimony to the great similarity the results bear to each other. For instance in 1851 for several tides before and after the new moon on June 29th, their float having passed Barking Creek opposite Plumstead Marshes from 2 to 2½ hours before high water, was carried by the stream as far up as the West India Docks, and in one instance as far as Greenwich.

"In my observations with the object in view to ascertain how far the stream extended which passed Barking Creek at two hours before high water there, I found that for two days before the full moon, June 18th, 1856, the stream stopped and turned at the City Canal and West India Dock entrance; on June 18th, it stopped at about 100 yards below or east of the West India Docks; continuing the observations on the ebb it was found to drift to Purfleet Lower Wharf, repassing Barking Creek at 3 hours 22 minutes after high water, thereby verifying the former observations in 1851, which were made at a similar period with reference to the moon's age.

"My further observations were made near the last quarter of the moon, or during the time of neap tides, when I found the stream considerably diminished, the volume of water passing Barking at two hours before high water being carried only as far as Hook Ness. There do not appear to be any observations made in 1851 with which I can make a comparison.

"In concluding my remarks on these observations I may venture to state from my own local knowledge of the river after being many years employed on it surveying, that I consider they have been taken with much care and reported with fidelity.

"I would now beg to remark upon the set and velocity of the main body of the stream on its passage from Plumstead Marshes opposite Barking Creek during the last two hours of the flood, and further, as far as my observations have informed me.

"In the first place the stream at two hours before high water at Barking Creek, or 35 minutes before high water at London Bridge, sets from the upper part of Barking Reach towards the house on the north shore called Duval's House, the main body being one-third nearer the Essex shore; from this position (off Duval's House) it sets directly for the eastern or lower part of the Royal Arsenal, there being a slack stream along the south-east shore of Gallions Reach from the east end of the Arsenal off the canal and along the shore forming the east side of this reach.

"At this position near the Royal Arsenal the main body of the stream with all matter held in suspension, would be set on the flood tide, whilst that portion which is set towards the canal on the eastern shore, would be kept in or near that position until carried away by the ebb tide.

"From the Arsenal the main portion of the flood stream occupies that part of the Reach which washes the shore at the town of Woolwich, running with considerable strength by Roff's Pier and Hog Lane, setting mainly along the line of moorings off the Royal Dockyard, close to which a vast quantity of silt accumulates from local causes on both streams.

"On the north shore opposite Woolwich the flood stream is not so strong, and close to the North Woolwich Pier, and on either side of it, there is an eddy on the flood. From the Royal Dockyard upwards the main body of the flood stream takes a mid-channel course until it reaches the Victoria Docks, when it sets bodily towards the East India Docks, Blackwall Pier, and the West India Docks; this is on the average the extreme western limit that sewage would atttain during a week of springs, if started into the river at Plumstead Marshes opposite Barking Creek at two hours before high water; during the week of neap tides, it would extend only as far as Hookness, much always depending upon the quantity of Freshes after heavy rains, which tend to impede the flood and accelerate the ebb.

The velocity of the stream at springs was found to be as follows: from two to one hour before high water, 2·7 miles (statute) per hour; from one hour before until the time of high water, 1·9 miles; from high water at Barking until the stream slacks at Blackwall it runs about 35 minutes longer and three quarters of a mile further. During the neaps a diminution of the above velocities takes place of about one-third of the above.

"The ebb tide from Blackwall ran down to Purfleet Lower Wharf on the day of full moon a distance of 12½ miles. The ebb tide from Barking Creek starting at high water slack two days after full moon ran down 14 miles, or to Pitcher's Building Yard at Northfleet, thus giving the eastern extent of sewage (started at high water slack off Barking) at Northfleet, and the western extent (as started two hours before high water) at the City Canal or West India

*Capt. E. Burstal, R.N.*

6 Dec. 1882.

Docks as remarked before. These refer to ordinary springs.

"The neaps will be as follows:—The ebb tide from Barking Creek starting at high water slack two days after quarter moon or neap tides, reached Grays, a distance of 11¾ miles, thus giving the eastern extent of sewage (started at high water, Barking), at Grays, and the western extent (as started two hours before high water), at the upper part of Woolwich Reach.

"Excepting in such instances as that of June 26th, when the wind comes suddenly from the north-west, there is always a longer duration of the flood stream and a greater rise of tide than under ordinary circumstances. The contrary will take place with strong southerly winds, the ebb streaming longer and the water falling lower.

"In concluding my remarks, I beg to call your attention to the accompanying table, which contains a detailed account of the observations I have made," then the table is appended.

6492. (*Chairman.*) Are those facts and views in your opinion, correct now?—They were quite correct then, and I have no reason to alter my views of the set of the stream now.*

6493. (*Mr. Lumley Smith.*) The table which is appended to that report, I believe, contains the result of the observation of the stream in June 1856?—It does.

*The annexed table was handed in.*
(*See* Appendix C.)

6494. Has the causeway at Erith been lengthened more than once, to your knowledge?—Not that I know of.

6495. I believe that first there was a floating barge put there?—There was a floating causeway put at the end of it kept down by chains, but I do not remember any other. A long petition came from the Erith people, a copy of which you have, and all the proceedings of the Board in reference to it, engineer's report and all.

6496. In 1882 did you have experiments made as to the drifts of the tide from Halfway House Point or Leather Bottle Point?—I made them myself. I gave evidence about them just now.

6497. Are you speaking now of those that were made in July 1882?—Yes; I made them with the harbour master on board the vessel, because I was anxious to know whether that stream ran with any force down the south side of the channel in consequence of the removal of the spits.

6498. You have more practical knowledge of the subject than I have; you think you have given us sufficiently the result of your experiments?—I think so.

6499. I believe you have the notes made by you on the stream drifts in the Thames on the 14th of July this year?—Yes.

6500. Will you hand that in?—

*The witness handed in the following paper.*

"Stream Drifts from Barking Creek down on the first of the ebb, July 14th 1882, strong wind S.W. High water at 1.0 P.M.

"Put drift pole into river close to buoy, inshore close outside northern outfall.

"This drifted close along shore at Barking Creek down to False Point (northern side of Barking Reach) thence set outwards towards the middle of the river, and towards Kent shore, passing Leather Bottle Point, Halfway House about one-third river over from the southern shore—thence it set over towards the northern side of Halfway Reach and drifted down through the northern or deepwater channel, and was taken up at 2.50 P.M. in the channel below Dagenham Jetty.

"Course of three sets of drifts from Halfway House Point or Leather Bottle Point, July 14th 1882:

"First drift started 2h. 10m. P.M. 1h. 10m. after high water.

"Quarter over from (No. 1) Ice House 39° 20′, High chimney 103° 50′, Magazine Jetty, south side.

"Halfway House (No. 2), 2h. 25m., Ice House 86° 30′. High chimney 78° 30′ Barking Reach.

"Point (No. 3), Magazine Jetty 73° 30′, High chimney 62° 0′, Halfway House.

"Jenningtree Point about 350 feet off Dagenham Jetty.

"Velocity of current 2¾ miles an hour.

"Second drift started 2h. 15m.

"Half Channel over (No. 1), Ice House 39° 30, High chimney 87° 0′, South Magazine.

"Opposite Halfway House Point (No. 2), 2h. 28m., Magazine Jetty 60° 50′, 59° 0′ Halfway House.

"Jenningtree Point. This drift comes close inshore in line 300 feet above Dagenham Jetty.

"Velocity of current 2¾ miles an hour.

"3rd Drift. Three-quarter channel over from Halfway House Point 1h. 20m. after high water.

"2h. 17m. P.M. Ice house 41′ 0″, High chimney 15° 30′, Halfway House.

"2h. 31m. P.M. This drift pole was set over to a point about 700 feet above Dagenham Jetty and was close to the ground.

"Stream drift from a point 100 feet outside low-water mark at Leather Bottle Point, about 1,000 feet above Halfway House.

"Commencing at 3h. 10m. P.M. or 2½h. after high water.

"3h. 10m. P.M. Stream pole, submerged 7 feet, over 100 feet outside low-water mark, or 150 from River wall.

"3h. 15m. P.M. Drifting parallel with round of point about 500 feet off the upper corner of the wall of outfall works.

"3h. 20m. P.M. Ice House 112° 10′, Chimney 109° 30′, Halfway House drifting over the inner part or little south of Mud Bank.

"Velocity of current 2½ miles per hour.

"No time taken. Ice house 72° 20′, Powder Jetty 99° 20′, High chimney.

"3h. 32m. P.M. High chimney 95° 30′, Ice House 106° 0′, Powder Jetty, Jenningtree Point.

"3h. 36m. P.M. Drift pole setting nearly parallel to shore and about 500 feet from high-water mark.

"3h. 39m. P.M. High chimney 61° 50′, Ice House 132° 10′, Powder Jetty, Jenningtree Point, 500 feet off corner river wall below magazine."

"N.B.—The velocity of the current calculated by the time and length of this drift along the south shore close in from Leather Bottle Point is 2½ miles per hour."

Cross-examined by Mr. Bidder.

6501. You have given some evidence with reference to the accumulation of mud in Erith Bight, and, as I understand, your suggestion is that that is caused by the sewers?—It is caused by the dirty water from the sewers. That is my opinion.

6502. I want to get this very clearly before the Commission. You are the Secretary of the Thames Conservancy?—Yes.

6503. And you have taken an active part in the management of their business for some years past?—Yes, as far as my duty is concerned; but not in the management of it.

6504. You were consulted and were engaged in the late arbitration which took place between the Con-

* Captain Burstal afterwards gave in a subsequent letter to Sir Benjamin Hall, dated 18th November 1856. A copy of this is printed in Appendix L.

servators and the Metropolitan Board of Works?—Yes, I gave evidence.

6505. That arbitration taking place at the instance of the Conservators?—Yes, originally.

6506. Who had under one of the Metropolitan Acts, the right to require the Metropolitan Board of Works to remove any mud banks which had been caused by the sewage?—That was the origin of it.

6507. And therefore the subject matter between you and the Metropolitan Board of Works in that arbitration was what mud banks?

(*Chairman.*) Surely that will appear from the arbitration.

(*Mr. Bidder.*) The arbitration is not referred to the Commission.

(*Chairman.*) The submission was surely in writing, or in print.

(*Mr. Bidder.*) No, it was not; it is an arbitration under an Act of Parliament.

(*Chairman.*) Then the Act of Parliament will show what the submission was.

(*Mr. Bidder.*) I am asking the leading witness, and the manager of the business on the part of the Conservators, so as to bring the matter concisely before the Commission.

(*Chairman.*) Any material facts you are entitled to bring before us, but you are reciting the contents of an Act of Parliament, and the submission to arbitration, and you are going to found some question to the witness upon that. Your reciting it does not bring the matter before us.

6508. (*Mr. Bidder.*) It brings the matter to your attention, and it is agreed between the witness and me that I am correctly representing the subject-matter of it. (*To the witness.*) On that occasion you submitted, did you not, to the consideration of the arbitrators, these mud banks which you were prepared to charge against the Metropolitan Board of Works as being caused by them?—No, none of the mud banks at Erith were mentioned at the arbitration.

6509. Is it not the fact that you, having required, as you had the power to do, an arbitration to be held ——

(*Chairman.*) You want to press upon our notice certain facts about an arbitration. Surely, the way in which we can take notice of that is by your putting in the arbitration. If you will ask the witness what he said on that occasion you are entitled to do that.

6510. (*Mr. Bidder, to the witness.*) Is it not the fact that upon that arbitration the only banks of the River Thames in respect of which you sought to fix us with a liability were the three banks at Dagenham, and Crossness, and Margaretness?—They were the only three banks elected by the conservators to go before the arbitrators. I had nothing whatever to do with the question of how many mud banks were before the arbitrators.

(*Chairman.*) That shows the great importance of our seeing what the submission was and what the award was.

(*Mr. Bidder.*) It was a power to take us to arbitration under an Act of Parliament. It was not a submission in the ordinary sense. The Act of Parliament gave them the right in case they were of opinion that we were causing mud banks in the river, and so obstructing the navigation, to require their removal, and if there was a dispute as to the fact, to take us to arbitration. The arbitration did not proceed on any definite issue as to any particular mud banks; but we came before the arbitrator, and the Conservators were in a position to charge us with any mud banks they thought fit.

(*Witness.*) What I said was this: that the only banks that were dealt with by me in evidence before the arbitrators, and the only banks that the conservators elected to have dealt with by the arbitrators, were the mud banks immediately in connexion with the outfalls in Barking and Halfway Reaches; and the Erith question was never gone into at all.

6511. But you know perfectly well that at that time when you came before the arbitrators it was open to the Conservators to have charged us with any banks that they chose?—If it had been so, even at the present time, the mud bank that the Erith people complain so very much about, is not any serious obstruction to the navigation.

6512. You have always considered that it obstructed the navigation, have you not?—No, you never heard me say a word about Erith until to day.

6513. I am not asking whether you said anything about Erith. You have represented to-day, have you not, that that bank has silted up the causeway, and interfered with people landing from ships?—Yes, I have said that.

6514. And in the same way has interfered with the causeway of the Corinthian Yacht Club?—Yes.

6515. Therefore it is in your judgment an interference with the navigation?—I do not know that that was known to me at that time; at any rate it did not occur to me when it went before the arbitrators, and I do not think it occurred to the Conservators at the time that it was worth their while to go into that question.

6516. You will agree with me that it was optional then with the Conservators if they pleased to bring the question before those arbitrators, whether this mud bank was caused by this outfall or not; but they did not do it?—It was quite competent for them to do so, but as they did not think proper to do so, I did not trouble myself about it—and I only do it now because the Erith people have complained of the mud, and they have asked me if I would look up the question, and I have looked it up, and I have given my evidence.

6517. My learned friend, Mr. Lumley Smith, asked you with reference to that spit near Coldharbour Point, opposite Erith Bight?—Yes, what you used to call Rand's Hill, is it not?

6518. Very likely I have called it by a wrong name, but you know the point?—I know the point, and I know the shoal.

6519. You said that that had been partially removed between 1832 and 1861; is it not a fact that a great portion of it has been removed since 1864?—I do not think so.

6520. Are you aware that dredging has been going on in that part of the river to a very considerable extent since the outfalls were open?—No, I am almost sure that it is not so. That the Rand's Hill has been dredged in that time I am ready to admit, and I know of that.

5521. Rands' Hill being as you say a little lower down the river?—Yes.

6522. And also towards the north shore?—No, it is as near mid-channel as possible.

6523. Can you tell me whether the sectional area of the river at that place is not greater now than it was before the outfalls were opened?—I have never measured the sectional area. I have never taken any cross sections. All I know is that a great shoal in the middle ground was taken away, which has very much improved the navigation. I do not believe much in these sectional area questions.

6524. You had charts of this part in 1878 and 1879, had you not?—In 1879, I think.

6525. Have you got those charts?—Yes, they are here.

6526. Could you let us have them?—Certainly.

6527. I suppose you know enough of the engineering question to know that the question of whether the sectional area of the river has been increased, or diminished, is a very important one?—Whatever alteration of the sectional area there may have been, it must have been a very small one, taking the whole breadth of the river. I know it cannot be very much, because I know the general breadth of the river, and the shoals that have been removed would not admit of a very great variation in the sectional area.

6528. You understand that if you deepen and enlarge the sectional area of this northern channel which is on the convex side of the bend, it necessarily has the effect of attracting the tide and the stream to

that side?—I do not see that any alteration which has taken place during 30 years in Erith Reach would cause this accumulation altogether in two or three or four years. All this mud has grown up in a very few years, and during all these 30 years the deepening has taken place in Erith Reach, that is to say, between Erith and Jenuingtree Point. The sectional area might have been enlarged as you say, but no deposit whatever has taken place at Erith; on the contrary there has been a considerable deepening in Erith Bight, and that can be shown by the sections.

6529. You have not yet answered my question as to the effect of enlarging the sectional area?—I cannot answer your question. I am not an engineer.

6530. You have made one statement that this mud bank has grown up in a very few years?—Yes, since the outfalls have been opened, and the water has been of a thick muddy character, which will, when it gets into slack water, deposit silt; whereas in former years, when it was clean water, there was nothing to deposit.

6531. Do you say that the water was clean water in former years?—It was very clean water when I was so much on it in 1833.

6532. Did you not yourself give evidence that the muddy state of it was frightful?—When?

6533. In 1866?—What part of the river was that in?

6534. I think it was before the Rivers Pollution Commission?—That had not reference to Erith, I am sure.

6535. Do you recollect being asked this question, "Was the Thames ever a very bright stream?" and your answer is "If you mean pellucid, I should think "not; but there is no doubt about this, that it was "far clearer before steamers were invented than it "has been since. It is the steamers that stir the "shore up. If you go down the river and watch "the action of a wave made by a paddle-wheel "steamer, it is something frightful. It will tear "away large masses as large as this table from the "saltings, and the rebound mashes up the muddy "portions of it, at least it mixes up the muddy "portions with the water and makes the water "turbid?"—I have no doubt that I did give that answer; but with reference to that I may be allowed to remark that if the paddle wheels of steamers made such a swell as to break off the banks of the river (which they did occasionally, doubtless,) the mud that is made by the earth mashed up, by the breaking off in that way, is nothing like the sort of mud that is to be found in these reaches now.

6536. The saltings that you spoke of are the marshy foreshore down in the neighbourhood of Erith, both above and below Erith, are they not?—I do know what I was alluding to at that place. I know the whole river very well, and I know that there was a considerable degradation of the saltings in some places by the washing of the paddle-wheels.

6537. Where are the saltings principally?—I can tell you all of them, if you like, beginning at Greenwich, and going to Greenhithe and Yantlet and Canvey Island. A great number of them have been stone pitched.

6538. (*Chairman.*) What do you mean by the saltings?—The saltings are the green swards that lie between the back river walls, and where the bank goes off steep and forms a foreshore, on which saltings thousands of cattle feed during neap tides, and they are driven off during spring tides.

6539. (*Mr. Bidder.*) They are called saltings because the high water impregnates them to a certain extent with salt?—Yes, and the cattle like it.

6540. That was, according to your experience, the old condition of the river before these outfalls were opened, that the steamers lashed up the water and tore away masses of the saltings as big as the table, and then churned them up with the muddy portions, and so produced that turbid condition of the river?—No doubt that was so to some extent.

6541. That always has been so since steamers have been going up and down the river, has it not?—Yes.

6542. And always will be so?—I do not know.

6543. (*Chairman.*) Do the screw steamers turn up the water in the same way as the paddle steamers?—The screw steamers do not make such undulations, but when they come up Halfway Reach, where a new shoal is formed a mile long, on the young flood, they churn up that mud, and it brings the muddy portion of that shoal up to the flood tide, and that makes shoals on the flood.

The witness withdrew.

Adjourned to Tuesday next at half-past 12 o'clock.

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# TWELFTH DAY.

## Tuesday, 12th December 1882.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.

(*Chairman.*) A question was put to Captain Burstal with respect to what he had done, or had not done, before a certain arbitration. I have looked at that arbitration, and I find that it amounts to this: under one of the sections of the Thames Conservancy Act, the Metropolitan Board of Works and the Conservancy Board were directed to refer to arbitration any differences that might arise either as to any acts done by the Metropolitan Board of Works with respect to the origin of any mud banks, or as to their being an obstruction to the navigation. Differences did arise, and two gentlemen of great eminence were appointed arbitrators between the parties, and those differences were at once carefully laid down and limited for the consideration of the arbitrators, in three propositions. The first was, what was the origin of three particular banks at Margaretness, at Barking, and at Crossness? Secondly, were those banks an obstruction to the navigation of the river? Then there was a third negative proposition, that the pollution of the river by sewage as a sanitary question should not be gone into. Then the arbitrators came to certain findings.

We need not enter into what those findings were, inasmuch as they have no bearing upon our inquiry.

(*Mr. Bidder.*) You have, Sir, if you will allow me to say so, stated it very nearly accurately, except in one or two minor particulars. The arbitration proceeded in the way you have described under that Act before the arbitrators and an umpire appointed by themselves, Sir Charles Hartley. Speaking from recollection, I think you will find that previously to their meeting in the arbitration, there was no limitation whatever of the question. The question raised was the liability of the Metropolitan Board of Works in respect of mud banks caused by them, and I might say generally, and in the earlier stages of the case, before it came before the arbitrators, there were certain statements and reports to the Conservators published, in which was shadowed out a case charging the Metropolitan Board of Works with nearly all the mud banks up and down the river. There was nothing in the nature of pleadings or of limitation before we came before the arbitrators. But what happened when we did come before the arbitrators was that my learned friend, Mr. Pope, who opened the case, said that he intended to direct his evidence to those three banks, which you, Sir, have mentioned. He said, "There are other "banks; I do not definitely withdraw them, but you "probably will not hear much about them." In fact, he elected to win upon those three banks.

(*Chairman.*) But after all, the question is what the arbitrators had before them. Surely I have stated correctly what the point before the arbitrators was.

(*Mr. Bidder.*) Ultimately it resolved itself, as you have stated, into the question whether the three banks were caused by the sewage outfalls, and whether they were an interference with the navigation; and you are quite correct in saying that the question of river pollution was not before those arbitrators in any way whatever. But the question whether those banks were caused by the sewage outfalls was a question before them. Of course I entirely agree that this Commission are not stopped, and cannot be stopped, by anything took place upon another occasion. At the same time, I thought it right that the Commission should know, (because probably you have no desire to take more upon your shoulders than you have, which is enough at any rate) that that question as to whether the sewers had produced an actual physical accumulation of mud in certain parts of the river, had been, I think I may say, most exhaustively threshed out before a very competent tribunal, and the result was an unanimous decision in favour of the Board. Further than that I do not wish to carry it.

(*Chairman.*) So far from its being an estoppel, if the question was identical, I should look upon this as a new trial.

(*Mr. Bidder.*) No doubt, and a new trial under circumstances under which one would hardly expect it ought to have been granted, as the award was the unanimous verdict of very highly competent judges. As regards the particular bank in Erith bight, it was referred to, but it was not followed up. In point of fact, the question was the same as regards all four. If you have the report before you, perhaps you will allow me to read one passage from the opening speech. My learned friend, Mr. Pope, who opened the case for the Conservancy, said, "If you will kindly look "upon the cartoon upon your right, it shows three "main banks, one immediately opposite the southern "outfall, one in slack water a little seaward of "Barking Creek, and a third, not so large but "increasing and in course of formation, on the oppo-"site side of Barking Creek by Margaretness, and "the Conservancy allege that those three banks have "been caused by the outfall of the sewage from the "northern and southern outfalls. I propose in the "course of this inquiry, mainly to direct your at-"tention to the question of these banks." Those were the three banks as to which they had the strongest case, and they felt that if they could win upon any, it was upon those, and of course we feel that it is a little hard, after we have beaten them upon their strongest horse, to have the same horse brought out of their stable again.

Captain Edward Burstal, R.N., re-called.

Further cross-examined by Mr. Bidder.

6544. I was cross-examining you with reference to your evidence in 1866. You have known the river for a great many years. The condition of the river was very bad before the outfalls were opened, was it not?—The condition of the river in the neighbourhood of London was very bad.

6545. And all the way down to Barking?—Not that I am aware of. I know it was very bad all about London, and, probably, I should say, from Greenwich, beyond where we are now.

6546. It always has been and almost must be a muddy river; is not that so?—That depends upon what sort of mud it is. No doubt there always has been a quantity of mud in the river; I do not know whether there always will be or not; but when I knew the river first I can conscientiously say that there was very little mud floating about in the lower part of the river, or, in fact, all over the river. The sewage has been poured into the river since, I think, 1845, and since that the river has become filthy. In 1857, 1858, and 1859, and so on, the upper part of the river was in a most horrible state in the neighbourhood of the metropolis.

6547. But, apart from any question of the effect of sewage either before or after the opening of the outfalls, have there not always, according to your long experience and observation, been, in all parts of the river, large quantities of mud stirred up, as you described in the answer which I read to you, by the steamers, swept up the river by the in-coming tide, and deposited all the way up the river even as far up as Richmond?—No doubt there was a quantity of mud, and there always has been a quantity of mud floating about in the water of the river.

6548. I see, in 1866, before the Commissioners, you were asked this question: "We have had it "stated in evidence that the in-flowing tide takes up "vast quantities of mud, and deposits it upon the "shoals and banks below Richmond?" and your answer then (and you will probably give the same answer now) was "No doubt that is so. The shores "of the river are muddy, and are stirred up by the "action of the steamers; the consequence is that "the water is made turbid, the stream carries it up "the river, and then, at slack water, where there "are no steamers, mud is deposited." Do you agree with that now?—No doubt it was so.

6549. Then, I see you also describe the condition of the river in 1856 and 1857 as being most filthy; that you adhere to still?—Yes, I said that just now.

6550. Then you went on further to say: "The "whole contents of the sewers went into it, and "then the sewage oscillated up and down, passing "London?"—Yes, that was so.

6551. "The river there had not the same power as "at Barking Creek to carry it to the sea;" is that so?—I do not quite know what that was, but I know this, if I may be allowed to make the remark, that then, as now, the stream would flow from the upper part of the river down, probably, to Greenwich, and then the next flood would come and meet it, and carry it back again; and I think that the oscillation that I referred to there must have been the oscillation of the river water that began to get polluted at a certain period of the ebb tide, when the flaps of the sewers began to get opened, and the sewage water ran into the river; and the consequence was that the stream had not time to carry the water, then polluted,

very far down the river, before it was met by the flood tide.

6552. Of course it is a long time ago, and your memory, like that of the rest of us, has limits to its capacity, and therefore I am endeavouring to refresh it. The purport of your evidence then, I take it, was this: if sewage were poured in at Barking, according to the experiments which you made, and which you gave us the other day, it would be carried out to sea at the rate of five miles a fortnight?—That was the conclusion I came to.

6553. But, on the other hand, you said that, under the then existing state of things, when sewage was put in here in the metropolis, it did not get carried out to sea at all, but oscillated up and down in the river?—I cannot say that none of it would go to sea at all; but the main body of the water in the metropolis, that is to say, from Chiswick, and all the way to Richmond, went floating up and down, and getting charged every 12 hours with the stuff from the sewers.

6554. It would be fair to you if I read the whole of your answer. The question was No. 9,080: "But, "before intercepting sewers were formed, the river "had the appearance of a foul stream?" and your answer was "Yes; when I was employed on the "survey in 1856 and 1857 the river was in a most "filthy state. The whole contents of the sewers "went into it, and then the sewage oscillated up and "down, passing London. The river there had not "the same power as at Barking Creek to carry it to "the sea. I made other experiments that were never "reported upon. I found, when the river was in a "normal state, that if I put floats in at high water at "Waterloo Bridge, they would go a certain distance "down the river on an ebb tide, and with the next "flood tide would come up to Waterloo Bridge again. "The sewage would be oscillating up and down "within the metropolis, I have no doubt, for "months?"—That is exactly the same as the answer I gave just now.

(*Chairman.*) What is the date of that opinion?

(*Mr. Bidder.*) That was given on the 7th of February 1866, before the Royal Commission appointed to inquire into the best means of remedying the pollution of rivers.

(*Mr. Michael.*) Mr. Rawlinson, Professor Way, and Mr. J. T. Harrison, were the members of that Commission.

(*Mr. Bidder to the witness.*) Then I see you were asked, "How far up the Thames would sewage, dis- "charged in the neighbourhood of Barking Creek at "low water, reach?" and your answer is, "It never "ought to be discharged at low water; and I believe "that the only reason for its being so discharged is "because the works were not sufficiently advanced. "I think there is no discharge now at low water."

6555. If discharged at low water, how far would the sewage reach up the Thames?—To Vauxhall Bridge.

6556. (*Chairman.*) What is the velocity of the inward flow?—On the average $2\frac{1}{2}$ miles an hour.

6557. And the ebb outflow?—Probably $2\frac{3}{4}$ and a little more.

6558. "(*Professor Way.*) The reservoirs, I believe, "are made of such a capacity as to hold the whole of "the sewage during a certain time? (*A.*) I believe so. "The sewage should be discharged at a given time, "just before or not far from high water. It might "then find its way a little way up to Woolwich, but "the next ebb tide would take it away and it would "never be seen again." Do you still adhere to the views which you then expressed?—I do not adhere to that last paragraph which you have just read, in which I say that it would never be seen again. That was a sort of *façon de parler* more than anything else; it would have been ridiculous if I had said such a thing as that in its literal meaning, because I knew at that time, and I showed by my own observations of the flow of the stream, that the floats, which, if I may be allowed to say so, represented the water in which they were placed, started away on the first of the ebb from Barking; and, if I remember rightly, on a spring tide they went a certain distance down the river, and they returned and went further up the river than Barking, sometimes as far as Blackwall. Therefore, if the water in which those floats were then put remained charged with sewage in its contaminated state, the answer that I gave at that time could not be said to be literally correct.

6559. (*Mr. Abernethy.*) May I ask whether, when you gave the answer which the learned counsel has just read to you, it was under the impression that the sewage was to be discharged on the ebb tide and the ebb tide only?—Yes, at high water.

6560. (*Mr. Bidder.*) A little before and a little after high water. I always like to be fair with a witness, and it is only fair that I should read to you your next answer, in which you said that you would much rather see the sewage discharged further seaward?—I think it would have been better if it has been discharged lower down, and discharged in a part of the river where there was a stronger stream to carry it away.

6561. You gave further evidence as to the effect of the malaria from the river upon persons living by the river, and upon the men who worked upon the river, in producing sickness and even peculiar diseases which were specially treated at the hospital?—I remember very well all the circumstances connected with that, and if you want me to repeat them from memory, I will do so with pleasure.

6562. It is a fact that the condition of the river was such that the malaria produced vomiting and sickness in those who worked upon the river, and upon yourself amongst others, and a peculiar affection of the mucous membrane as you described?—That is quite true.

6563. Then taking another answer which you gave with regard to the mud, you pointed out that a very considerable supply of mud was drawn from below these outfalls at a place called Northfleet, and in that neighbourhood?—The mud coming into the river from near Northfleet was what broke off from the saltings.

6564. But you evidently considered that at that time to be a very important source, because you were asked by Professor Way, at question 9121: "As to "the pellucidity of the river. From what you have "said, I infer that as there is really no bringing up "of matter from below, but merely the stirring up of "that which already exists, tidal action ought, after "a time, to rid us of the mud? (*A.*) There will be "a large quantity of fresh water constantly going "down, and there will not be muddy water coming "up. I believe that the water of London will be "cleaner than any man alive has ever seen it. "(*Q.*) Do the steamers produce mud from the bed "of the river, or merely stir up that which has "already come down? (*A.*) They produce it; they "break off the banks. (*Q.*) I mean above bridge? "(*A.*) No, I think they merely stir up what is there. "(*Q.*) Then we ought to get rid of it, ought we "not? (*A.*) No, for this reason, you get a fresh "supply from below. There is a place at North- "fleet where the waves from the steamers strike "against the banks and break them away and thus "form mud. (*Q.*) That mud would not come further than London Bridge? (*A.*) Yes, it would?" —Yes, I should think that is quite correct. I do not see any reason to alter my opinion as stated then.

6565–9. Another question which I am tempted to ask you is this: It was your observation at that time that the fish had already to a great extent disappeared from the upper parts of the river, was it not?—What do you call the upper parts of the river?

6570. Here, and down at Greenwich and Woolwich?—Yes, I think they had.

6571. Before the outfalls were opened?—Yes, I think it was before the outfalls were opened that the eel schuyts went away.

6572. That is all I have to trouble you with on that evidence. Going to the question of mud and dredging, and the condition of the river in Erith

Bight opposite Erith, is it not the fact that either the Conservators, or the Trinity House, or private dredgers have since the year 1864 dredged very large quantities of material from the river, especially from the northern side of the river, in that part which is opposite Erith?—I do not believe they have—or not since 1864.

6573. You have returns as to the dredging, have you not, in the records of the Conservancy?—No.

6574. You produced certain returns on the last inquiry, did you not?—I do not remember. Mr. Smith, the master of the steamer, had something of the sort.

6575. A statement was put in by a gentleman of the name of Ellis James Smith; is he an officer of yours?—He was; he is dead now.

6576. I think he put it in as purporting to come from your records?—It came from his log-book.

6577. At page 260, there is a table showing the comparative amount of dredgings done in Blackwall Reach and the Rands from 1859 to 1879; and he states that he had been actively employed as commander of the "Conservator" steamer for upwards of 20 years. You have no doubt that that table was prepared from the records of the Conservancy and their officers?—I am quite sure that whatever Mr. Smith put in was correct; but I should like to see what the table was.

6578. It is a table showing the comparative amounts of the dredging for the last 20 years?—He kept it either in his private journal, or else it was put in his log book. Mr. Smith says that he took every day in his book an account of the position of the dredger, and that from those accounts he made out the return.

6579. If you will take the compartment of the river which is headed "Erith Reach," you will see that that table indicates that from the year 1871 onwards a very large amount of dredging was done in that part of the river.

(*Chairman.*) That is, that there were certain dredgers anchored there. That is what this paper shows.

(*Witness.*) I see in 1864 he has a dredger for one month.

6580. (*Mr. Bidder.*) But I referred to the year 1871; there was not very much before 1871?—There is nothing in 1871 at all in the north part of Erith Reach except "three months, Lower Coldharbour."

6581. Erith Reach, off Rainham, in 1871, five on the north side, one on the south?—But that is not Erith Reach.

6582. Off Little Coldharbour, none; off Lower Coldharbour, three on the north side. Then, in 1872, you have one on the north side off Rainham, 12 on the north side off Lower Coldharbour. Then, in 1873, three off Rainham, two off Little Coldharbour, one off Lower Coldharbour. Then, in 1874, 15 off Rainham, and four off Little Coldharbour. Then, in 1875, 15 off Little Coldharbour, and five on the south side. In 1876, 10 off Little Coldharbour, and five off Lower Coldharbour, all on the north side. I will not read them all in detail. Have you any reason to believe that those do not accurately represent, I will not say the quantity, but the extent of the dredging?—I daresay they do. I suppose they were bag and spoon dredgers.

6583. And they were put in on the last arbitration for that purpose?—Not by me; by Mr. Smith. I never saw them.

6584. But they were produced by the Conservators—No doubt.

6585. The last division on that same page gives the dredging off Erith, of Rands Reach?—Yes, that is below.

6586. And that shows generally that a great amount of dredging there took place, beginning in 1862, 1864, and 1865; not quite so much in 1866, in 1867, and so on down to 1871, when it appears to have stopped?—That is when the Rands Hill was taken away. Rands Hill is below Erith.

6587. With regard to these experiments which you made in 1856, there appears to have been some question as to whether Sir Joseph Bazalgette took part in them or not. I believe, in point of fact, you conducted the experiments, and he was present as representing the Metropolitan Board?—No. It was just in this way, in a very few words. Sir Benjamin Hall was the First Commissioner of Works. In 1856 he asked the Metropolitan Board of Works to supply me with a copy of Mr. Frank Forster's tidal experiments in 1851. The object of my making experiments was for the purpose of testing Mr. Frank Forster's experiments for the satisfaction of the First Commissioner of Works, as to the flow and reflow of the stream, in order that he should be satisfied that the sewage that was ejected into the river at a certain point would not flow up to London.

6588. (*Mr. Balfour Browne.*) Those were the experiments spoken to by Mr. Phillips upon the last occasion that the Commission sat?—Yes. I had an interview with Mr. Bazalgette, who was engineer to the Metropolitan Board of Works, and he came to Woolwich and saw me, and I pointed out to him the mode which I intended to adopt in making the experiments, in order to have a fair and honest comparison with the experiments made by Mr. Frank Forster. That is all that Mr. Bazalgette did. He came with me for about an hour, but he never went down the river with me.

6589. (*Mr. Bidder.*) Of course it is some time ago, and I am sure you are speaking to the best of your recollection; but I must ask you to press your memory a little more, because I have in my hands the order of the Metropolitan Board that Mr. Bazalgette should be appointed by the Board to meet Captain Burstal for the purpose of verifying the experiments referred to?—Well, he did meet me, and he was with me for about an hour at Woolwich; and that is all I saw of him and all he saw of me.

6590. I must leave it there till he comes?—I shall be very glad to see him, and to remind him of the hour he passed with me off the Point at Barking Creek. Then he went to Woolwich, and I never saw anything more of him.

6591. Neither you nor Sir Joseph Bazalgette would be anxious to say anything to the detriment of the other; but, apparently, there is some little divergence in your recollections, and I must leave it till he comes to clear it up?—I shall be quite satisfied.

6592. With regard to Erith, a place where you say the mud has been accumulating, is it not the fact that the sectional area of the river at Erith is greater now than it was when the outfalls were opened?—It must be so to some extent, because, as you said just now, dredging has been done there. But what I say is this: that if you dig a great hole in the river you merely make a pond; you do not increase the sectional area in such a manner as to affect any other part on the opposite side of the river. But if you dig a hole in the river, and communicate with that hole from all parts of the river for a long way above, making a gutway into that hole, and an opening from that hole for the water to escape to the lower part of the river, then you will doubtless cause something to happen which will have a tendency to draw the water into that gutway, and into that hole which is dredged; but not otherwise. I have some sections which I only plotted a few days ago, which are quite at your service, by which you will see that dredging has been done at a certain part on the north side, the Essex side, and just above and just below that dredging, the river bed is just where it was many years before; so that I cannot, for the life of me, see that because you dredge a hole or scratch away a few banks on one side of the river, where there are probably eight or nine feet of water, you necessarily create such a divergence of the stream as to cause the other side of the river to be slack.

6593. Do you not see that your reasoning is proceeding a little too rapidly, and that it does not follow that because you have dredged one part of the river, and left the portion above and the portion below as they were before, you have dredged a hole? It may

be that the part of the river you have removed was more contracted and shoaler than the parts above and below, and that you have removed by that particular dredging, at a particular spot, that which to a certain extent diverted the tide previously?—I do not think so. I am prepared to state what I have not stated before, for I did not know it for a fact until this morning, and that is this: that the large middle ground in Erith Reach was removed before 1853.

6594. What do you call the large middle ground?—The large middle ground was about there (*pointing it out*), and the shoal that we have been talking about, off Coldharbour Point, was about there (*pointing to it*). That middle ground was removed before the year 1853, and in 1853 the Trinity Board put their dredgers upon that shoal. I have a little plan that I got from the Trinity House, and I think there will be sufficient evidence to show that a great part of the dredging that was done in Erith Reach was done in 1853 (*producing a plan and describing it*). That is where the large shoal was in Erith Reach. This chart was prepared by the master of the Trinity dredger that was at work there then.

6595. What was the name of the dredger?—I do not know.

6596. Is he a gentleman who is accessible now?—No; he is dead. This chart is "drawn by H. Parker, "master of the 'Goliath' dredger, pursuant to orders "of the supervisors of the Ballast Office." This was lent to me this morning by the Trinity House, and there is the spot where the middle ground was formerly, and, as you see here, it was removed then, and in 1853 they put the dredgers upon the shoal just above Coldharbour Point, so that I presume it was there, perhaps, for a year; I do not know how long. (*The witness handed the plan to Mr. Bidder.*)

6597. The chart, if I follow it rightly, appears to show that what you call the middle ground in Erith Reach, which is a shoal about the middle of the Reach, rather on the south than on the north side, was removed at that time?—Yes, in 1853. It was nearly in the middle of the river.

6598. At any rate it says "worked ground"?—Yes.

6599. It also appears to represent the dredgers as being located just above Coldharbour Point?—Yes.

6600. But it does not show when, subsequently to that time, the dredging was completed?—No, it does not do that. I only produce that plan for what it is worth.

6601. You answered me that you would not deny that the sectional area of the river was increased opposite Erith; is it not also the case that that increase of sectional area has taken place on the northern side?—It must have been so, because the greatest part of the dredging did take place on the northern side.

6602. Do you remember giving evidence before certain other Referees, appointed by the First Commissioner of Her Majesty's Works, in the very same year, 1856?—I was associated with Captain Galton, and some referees there.

6603. With reference to what we were talking about just now, let me draw your attention to the report of what you stated to the Referees then, in which you expressly said that Mr. Bazalgette was present at one of the experiments, which you described, in which you put the float down?—I think I have said just now that Mr. Bazalgette came to Woolwich, and he came off in a boat to me when I started these experiments. I pointed out to him the mode and the time of making these experiments, with which he perfectly agreed; and I am quite sure that if Sir Joseph Bagalzette is in this room now, or if he comes, he will tell you that he never went one yard down the river with me beyond the point.

6604. You said, "Another float put in at Barking "two hours after high water floated down to Long "Reach on the ebb and back as far as Charlton Pier "with the flood. Mr. Bazalgette was present at these "experiments"?—Did I say that?

6605. You are reported in print to have said it?—Just so; but Mr. Bazalgette was not down the river drifting with the drift, and coming back with it; he was only with me when I started, I assure you.

6606. That is what you said about it when it was fresh in your memory?—I am quite certain that Mr. Bazalgette was never with me half an hour in a boat in his life. He came down from Woolwich to Margaretness Point, and he went back. I am certain of it.

6607. It is possible that your recollection within a few days of the occurrence, nearly 30 years ago, may be more accurate than your recollection now?—That is quite possible.

Examined by the Commission.

6608. (*Mr. Abernethy.*) You know various important tidal rivers in this kingdom, I suppose,—the Humber, for example?—I do not know the Humber very well. I have been up it two or three times.

6609. You know that, generally speaking, other tidal rivers are quite as muddy, if not more so, than the Thames?—Yes; so is the Medway.

6610. Do you recollect where the outfalls of the metropolitan drainage were first proposed to be made?—Yes; on Greenwich marshes, I believe.

6611. In 1856 you advised Sir Benjamin Hall upon the subject, did you not?—Yes.

6612. Where did you recommend that the outfalls should be?—I recommended that they should be lower down the river. First of all they were to be at Margaretness; and I said then, that if the sewage was put out at that point, it would reflow and get up to London frequently. Then they went further down into Halfway Reach; and even then I said that they ought to be lower down, at Rainham Creek on one side, if I remember rightly, and at Jenningtree Point on the other.

6613. (*Colonel Ewart.*) One mile above Erith?—About a mile above Erith.

6614. (*Mr. Abernethy.*) You are not aware that it was proposed originally to discharge about half a mile below Mucking lighthouse?—Yes; the Referees proposed that.

6615. And on the south side, four miles below Gravesend?—Yes; near Cliff Creek. That was what the Referees recommended.

6616. (*Colonel Ewart.*) When you gave that opinion, that the points at which the sewage of the metropolis could be discharged without reflowing into the metropolitan area should be not nearer than Rainham Creek on the north side, and one mile above Erith on the south, did you contemplate that it should be discharged under certain conditions?—My opinion was always that it should be discharged at about the time of high water, and that the first set of the ebb stream would take it down as far as it could go, and that then it would reflow up to a certain point and back again, constantly going up and down twice every 24 hours. But I never thought that it would go up so as to pollute the inhabited part of the metropolis, such as Woolwich and Greenwich, and from there upwards. I thought that would be a safe point for starting the sewage from in order not to pollute the river in the neighbourhood of the metropolis.

6617. And provided that it was discharged at certain times?—Of course that is very material.

6618. Did you at that time consider the amount of sewage that was then going to be discharged, or did you look to the future?—I merely considered that the amount of sewage then being discharged would be all the sewage of the metropolis; I never thought of what was going to happen for the future. But

the system to be adopted was to put it into the river, and let it find its way down as far as it could, and then that ultimately the water would find its way to sea, and that the river passing through from Greenwich up here would be freed from all the filth with which it was then polluted.

Re-examined by Mr. LUMLEY SMITH.

6619. As I understand, the chief matter to be discussed before the Referees was whether, if it went to Barking, it would come up and poison London; was that the chief matter?—I did not go into that question before the Referees at all. I took some tidal drifts for them in Sea Reach, and they conferred with me on several occasions; and they came to the conclusion and made a report, that if the sewage was discharged on the south side at Cliff Creek, and on the north side a little below the Mucking lighthouse, they would never know it, even up as far as Gravesend. That I believe was their idea, and I believe it was what they stated.

6620. I see that in the evidence which you gave in 1866, in answer to question No. 9088, you say, "Supposing it possible, I think it would have been "better to have taken the sewage down to Northfleet "about the full end of the flood tide, and then let it "run off as it could, without any tank." You seem to have been then of opinion that it would have been better to take it as far as Northfleet?—I was of opinion, no doubt, that the further they could get it down the river the better; and if it could be put into a settling tank and precipitated, and nothing but fluid passed into the river, it would be very much less objectionable than it has turned out to be.

6621. Then you were asked this question by Mr. Harrison: "Supposing the sewage were dis-"charged 10 miles lower down, what would be the "effect?" and your answer was, "Ten miles lower "down is perhaps rather a short distance. If the "sewage could be always discharged by gravitation "at a point 15 miles lower than Barking Creek, and "allowed to mix with the water of the river, there "would be very little of it seen again." Do you still think so?—Yes; I should think that very reasonable and very fair.

6622. You were asked about the effect of steamers upon the mud, tearing off portions of the saltings; before 1866 were those steamers in full work?—I think it is only fair that the Commissioners should be impressed with one fact respecting steamers, and that is, that in those days we had very large heavy paddle-wheel steamers, paddling up and down the river, which made a much heavier sea, and disturbed the banks a very great deal more than the screw steamers do at present. You will have a screw steamer going along at present at a very quick pace making very little wave; nothing to be compared to the wave that the old paddle-wheel steamers used to make.

6623. Then, so far as the muddiness of the water is concerned, it would be less likely to result from the action of steamers now than it was before 1866?—I should think so. I do not think there are such heavy waves sent upon the banks as there used to be.

6624. But when you had those paddle-wheel steamers did you find the river in the same dirty, muddy condition that you do now?—Certainly not. Then it was really healthy mud; now it is filthy black mud. I have not been on the river very much of late years; but anyone who goes on the river and sees the character and colour of the water down from Woolwich to Greenhithe must know very well that that is not the colour that the river water used to be.

6625. Then I see that my learned friend asked you a question or two about what you said in 1866, as to the effect of the water in London on health. I see you mention that in 1858 and 1859, when the river was in a bad state, there was very little sickness on the river; do you remember that?—I do not believe there was much.

6626. 1858 and 1859 were bad years, were they not?—Yes, they were bad years; the river stunk most abominably.

6627. Did you find much illness amongst piermen and bargemen and Custom House officers?—No; I believe there was not much.

6628. I see you were asked, "May I take your "opinion to be that, although a river is very foul to "sight and very noxious to smell, it does only a "minimum mischief to health?" and you said "Yes" to that?—Yes.

6629. On the other hand, you have known cases of illness; you yourself have suffered?—When I was surveying the river I was generally at work at low water, when the river was very much charged with filth, and I was made sick with it; and many of the men on board the "Citizen" steamers were attended on by a nephew of mine, a Mr. Ord, who was house surgeon at St. Thomas' Hospital. He has told me that frequently. That was somewhere about the year 1856. As far as I was concerned it was very nauseous, and I very often had a sore mouth, and all the mucous membrane of my lips and mouth made bad by the offensive smell of the river.

6630. A word or two about this dredging. This table that my learned friend has drawn attention to was not prepared by you, as I understand?—No, it was prepared by the master of the steamer.

6631. You were going to tell us something about the spoon-and-bag dredgers, were you not?—I said, I thought they must have been spoon-and-bag dredgers. Most likely the master of the steamer counted the vessels that were working on the river, and they must have been spoon-and-bag dredgers; they could not have so many steam dredgers as that.

6632. Do spoon-and-bag dredgers raise anything like the quantity that the steam dredgers do?—No.

6633. (*Mr. Bidder.*) It is not the number of dredgers, it is the number of months the dredgers were working?—I did not prepare the table myself, and I cannot tell what he meant.

6634. (*Mr. Michael.*) The spoon-and-bag dredgers do not occur in the table at all?—I did not prepare the table, and I cannot hold myself responsible, or the conservators either, for what Mr. Smith said.

6635. (*Mr. Lumley Smith.*) That table does not show whether they were steam dredgers or spoon-and-bag dredgers?—No, I believe not.

6636. There are a great number of spoon-and-bag dredgers at work always, are there not?—There used to be.

(*Mr. Bidder.*) It is clear that these were not spoon-and-bag dredgers, because, if you will look at page 259, he was asked this question: "With regard "to this table which you have made, there is a dis-"tinction between the gravel dredged by hand-"dredging and other dredging? (*A.*) They dredge "for shingle ballast; they do not dredge to clear "the river, but for other purposes. (*Q.*) Have you "any record of the number of sand barges em-"ployed? (*A.*) No. There are barges dredging "with the bag-and-spoon from the bottom, and "others go on the foreshore, and they shovel it up. "(*Q.*) Have you any record of this work? (*A.*) No "record. This table has reference to steam "dredgers."

6637–40. (*Mr. Lumley Smith.*) The spoon-and-bag dredgers are people who dredge for their own profit and sell the gravel?—Yes, they sell the gravel.

6641. Who are the steam dredgers?—The steam dredgers that he refers to are the dredgers belonging to the Trinity House; and I think there were two private dredgers; one was a dredger belonging to Messrs. Hunter and English, and the other to Mr. Williams, I believe.

6642. (*Mr. Abernethy.*) The quantity dredged by the bag-and-spoon would be small, would it not, as compared with the quantity dredged by steam?—It

*Capt. E. Burstal, R.N.*

2 Dec. 1882.

would. A bag-and-spoon dredger would not hold more than 40 or 50 tons.

(*Chairman.*) That table was evidence which, I understand, was handed in by the conservators on a former arbitration, and they give credit to that evidence, and there is that answer of the witness, that that table only refers to steam dredgers.

(*Mr. Lumley Smith.*) That is so.

6643. (*Mr. Bidder to the witness.*) Perhaps you will recollect that you also handed in a return of the licenses which are granted to hand dredgers?—Yes.

6644. I believe the conservators grant licenses, for which a fee is paid?—Yes.

6645. And you have an accurate record of the number of those?—Yes.

6646. Is that (*handing a table to the witness*) the table you handed in?—That is it.

6647. That return came from your office also?—I suppose so. I have not seen it before.

6648. (*Chairman.*) Do you know anything about it?—I do not. It was produced by somebody; I did not receive it.

6649. (*Mr. Lumley Smith.*) Something was said about some contours; have you some contour sections prepared yourself?—No.

6650. (*Mr. Bidder.*) I presume you would have no difficulty in preparing now for the Commission a similar return to that?—No.

6651. Then I ask that that may be done, distinguishing eastward and westward of London Bridge?—Above and below the bridge.

6652. (*Mr. Michael.*) In every year there is a return of the amount received by the Conservancy for licenses granted?—Yes; I will get that return. (*See Appendix B T.*)

6653. (*Mr. Bidder.*) I see that amongst your accounts you have an annual account of the expenses incurred by persons for dredging below bridge. I find 6,021*l.* in your accounts of last year, "By cash, for expenses connected with dredging"?—But that dredging is merely dredging for moorings; I do not think that would be of any value to you at all.

6654. (*Mr. Abernethy.*) In making that return, do you specify the nature of the material dredged?—I am afraid we should not be able to do that.

6655. (*Mr. Bidder.*) I am told that your accounts for the year 1876 show 20,000*l.* expended in dredging. That could not all be for moorings?—I expect that that is more for the cost of new plant. It must have been so; it would include the cost of the dredgers.

(*Chairman.*) I do not see what bearing all this has on the case. We are discussing that one point at Erith.

(*Witness.*) I am sure we could not give you any information as to any quantity that has been dredged in any one particular part of the river, for this reason: a man takes out a license to dredge the river; there are certain conditions on the back of that license, and he can go anywhere he likes from London Bridge down to the Nore. Therefore we could not give you any information whatever respecting the amount taken from any one particular part of the river.

(*Mr. Lumley Smith.*) I understand that some careful sections have been taken of the river. I will take whichever course the Commission like. After Christmas I believe we shall have some careful contour sections that have been prepared, showing the capacity of the river, and so forth; and I can take Captain Burstal's sections with those other sections all at once, if you think that more convenient, or I will examine him upon them now.

(*Chairman.*) Do not let us get into the question of the obstructions of the navigation, because we must steer clear of that.

(*Mr. Lumley Smith.*) Or I can have Captain Burstal's sections handed in, and have them identified now; and my learned friend can see them between this and Christmas, and he can cross-examine about them after Christmas if he wishes.

(*The witness handed in some sections, see Appendices* D., E.)

(*Mr. Bidder.*) Of course these sections, if complete, may be very valuable, but at present they only tell half the story. What I would suggest is, that my learned friend and Captain Burstal should postpone putting them in until after Christmas, and that they should then put them in complete, so that they should show the whole river. At present they only show the south side, and not the north side.

6656. (*Chairman to the witness.*) Are these plans prepared under your superintendence?—Yes.

(*The witness described the plans to the Commission.*)

6657. (*Mr. Bidder.*) In these sections, if I follow you rightly, you have simply shown what has happened on the south side of the river, but you have not continued the sections so as to show what has happened on the north side of the river?—No; my only object in having these sections drawn was to show what has been talked of so much in this room by the Erith people about the deposit of mud at that place. You can have sections made upon the north side just the same.

6658. You know perfectly well that the answer to that suggestion of silting was that the silting was caused by the north side having been deepened?—No, I have never said so.

6659. You know very well that our contention on the last arbitration was, and would be again here, that the south side silted because the north side was deepened?—That does not follow at all, in my opinion.

6660. Will there be any difficulty, before the Commission meet after Christmas, in your completing these plans and sections so that they will show the same thing throughout the bed of the river across at the north side?—We can get a plan of the north side if you like.

6661. Have you the materials?—We have the plan, and the same materials as we had in the other case.

6662. Have you any objection to make the thing complete?—I have no order for anything of the sort; but I beg to say that what I have put in is perfectly complete, because it was done with only one object in view, and that was to show the great changes that have taken place in the bed of the river near to the town of Erith.

(*Chairman.*) You will be able to make your own plans, Mr. Bidder.

(*Mr. Bidder.*) Of course I can, sir; but if you will look at the way this is headed, it is entitled "Cross-" sections showing alterations in the bed of the river "off Erith;" whereas, when you look at it, it only shows the alterations in that part of the bed of the river which is on the south side.

(*Chairman.*) Take it for what it is worth. You will be entitled to make any remark you like upon the evidence; but what you now call upon the witness to do is to undertake the labour and expense of making sections or plans to supply you with additional evidence.

(*Mr. Bidder.*) Why not? He has all the materials.

(*Witness.*) You have the materials also.

(*Chairman.*) You cannot call upon this gentleman to make such sections. These plans are legitimately in evidence. Captain Burstal says that they have been made under his superintendence, and we take them as representing what they purport to represent, and nothing more. It will be open to the learned counsel to point out that they represent nothing; that they represent worse than nothing; that they are, in fact, worse than useless. But I understand Mr. Bidder to call upon the witness to undertake now to prepare for him an additional set of plans.

(*Mr. Bidder.*) Not for me. Remember, sir, that the Commission is here inquiring into a public question of great importance, and Captain Burstal is here as representing a public body, the conservators, who are laying certain materials before the Commission: that public body being those who have charge of the river, and who have peculiar facilities and opportunities for knowing what is going on, and having records of

the condition of the bed of the river, and having the materials ready. Knowing, and telling the Commission that my case will be, as regards this point, that what has happened on the south side is the result of what has happened on the north side, my application is that the Commission will ask that public body, having the materials, to supply them with the whole materials, which are relevant and necessary to decide the question.

(*Chairman.*) If they are materials which you can get by giving them notice to produce them you can give the necessary notice, and we shall see whether they produce them, or not. If they do not produce them, of course it will be open to you to observe upon it. But what I understand you to ask the Commission to do is to require the witness to prepare certain things. We can make no order upon the witness.

(*Mr. Bidder.*) As a Royal Commission you can call upon the conservators to supply the materials necessary for the purpose. They being a public body who have the custody of these records, I ask you to call upon them to supply us with the materials necessary to decide this question.

(*Witness.*) You have the materials yourselves; you have a copy of the chart that I left here last week.

(*Chairman.*) If you have any application to make to the Commission, Mr. Bidder, you can make it in the regular form; but I do not think that we need detain Captain Burstal longer.

(*Witness.*) I have not the power of doing it; I must submit these things to the conservators and get their consent.

(*Mr. Bidder.*) I simply make the application, and I ask you, sir, to call upon the conservators, and use your power to obtain the complete materials with regard to that portion of the river.

(*Chairman.*) The conservators have heard your remarks, and I have no doubt they will pay due attention to them.

The witness withdrew.

Mr. Edwin Hughes called in; examined by Mr. Balfour Browne.



6663. I think you live at Green's End, in Woolwich?—That is my office.

6664. You are solicitor to the Local Board of Health at Woolwich, are you not?—Yes.

6665. And I think you have been requested by that body to give evidence before the Commission?—Yes.

6666. How long have you lived and carried on business in the parish of Woolwich?—Since 1845.

6667. And I think you were a member of the Local Board for about 20 years?—Yes.

6668. That was previously to the time when you became their solicitor?—It was.

6669. I think you were for a time also a member of the Plumstead District Board, and also connected with the Plumstead Vestry?—I am on the Plumstead Board now, and have been for 16 or 17 years.

6670. So that you are very well acquainted with the locality and its sanitary requirements?—Yes. I am chairman of the sanitary committee for Plumstead at the present moment.

6671. I think you have also some connexion with the steamboat company, have you not?—I had formerly.

6672. You know the river very well?—Perfectly.

6673. And you have travelled upon it frequently?—Yes.

6674. Would you tell the Commission what is the condition of the river at Woolwich?—It is very bad in hot weather.

6675. Is it your view that it is getting worse?—Yes; but we have not had any hot weather lately.

6676. In your opinion, and in the opinion of the Board that you represent, what is the cause of this deterioration in the condition of the river?—Because the sewage is emptied at one spot where the outfalls exist.

6677. How is the sewage of Woolwich itself dealt with?—It goes into the main metropolitan sewers and is carried down to Crossness.

6678. Is that true of the drainage of North Woolwich?—No; from North Woolwich it is carried direct into the river at North Woolwich, and the sewage of part of East Ham too.

6679. Is there a reservoir for the reception of that sewage?—Yes, at North Woolwich.

6680. Was that made at the expense of the Metropolitan Board?—They contributed something towards it, but it was done by the Woolwich Local Board, because the Metropolitan Board would not go to the expense of connecting North Woolwich with their main system.

6681. I think that reservoir is situated just above the North Woolwich pier, is it not?—Yes; it has nothing to do with the main drainage.

6682. But it pours its sewage into the river separately?—Yes.

6683. Does any other district in your neighbourhood contribute to the sewage that passes through that outfall?—East Ham.

6684. Is it your view that this outfall contributes somewhat to the pollution of the river?—To a small extent it does.

6685. Do you know the condition of the river Lea?—I have been up it sometimes in a boat. It is, I should think, rather worse than the Thames, if anything.

6686. Its waters flow into the Thames, in your district, I think?—Not in our district; above our district, at Blackwall.

6687. Is it your experience, having known the river a long time, that at Woolwich there is an increase of the filth on the banks of the river since the opening of the outfall?—A great increase, and the colour is darker; it is black now, it used to be brown. It used to be a natural mud, and now it is not; it is an artificial mud.

6688. You have for a long time given especial attention to this question of the pollution of the river, have you not?—I have read a great deal about it, but I am not a scientific witness.

6689. But you have made yourself as familiar as you could with all the reports on the matter?—Yes; being on local boards I have taken an interest in the subject.

6690. Have you, from your reading and from personal inspection, been able to come to any practical opinion with reference to this question?—Yes, I have formed an opinion.

6691. What is your opinion as to what ought to be done with the sewage of London so as to improve the present filthy condition of the river?

(*Chairman.*) We should be glad to postpone this part of the inquiry for the present. We have first to inquire whether the present system is not sufficient. If it is sufficient we should not trouble the witness.

6692. (*Mr. Balfour Browne.*) It will be more convenient, of course, to keep the two branches of the inquiry distinct. (*To the witness.*) It is suggested on the other side that the smells from the river are indistinguishable from those from the factories; is that so?—I can distinguish between the two.

6693. And there is no doubt about the river having a smell of its own?—In hot weather certainly. I was requested by my Board to represent the great accumulation of filth on the river bank since the sewage has existed there.

6694. (*Chairman.*) Of what part of the river are you speaking?—Of the different shores of the river from Woolwich and below Woolwich, between Wool-

*Mr. E. Hughes.*

12 Dec. 1882.

wich and Erith. You cannot land from a boat now in many places where you used to be able to land, but you now come against a mud bank, and if you got out you would be suffocated.

6695. Is there a very considerable accumulation of this mud (as we will call it by courtesy) near the Woolwich pier?—There is some, but the worst part, of course, is near Crossness.

6696. And you told the Commission in the earlier part of your evidence that the colour of the deposit had entirely changed since the opening of the outfalls?—Yes, it is as black as ink.

Cross-examined by Mr. MICHAEL.

6697. Within what period do you say that you have noticed this accumulation of mud?—It has been very gradual; it began as soon as the outfalls commenced, and it has gone on increasing ever since.

6698. Have you been down there yourself?—I have noticed it getting worse every year.

6699. Was there no mud in 1864?—Not of the same character. There was mud prior to the opening of the outfall; but it was mud, and this is filth.

6700. Do you say that this mud is black on the surface at the present time?—Certainly.

6701. You have noticed that yourself?—I have, indeed.

6702. For what period have you noticed that?—For quite 10 or 12 years, and more I should think.

6703. And the mud before that was of an entirely different colour?—It was of an entirely different colour; it was not so dark in colour, and it was a different kind of mud altogether.

6704. Then do you say that at the present time the mud deposited, of which you complain, is black on the surface?—I do.

6705. And for how far does that extend?—I have tried to land at Crossness, and I could not find any bottom by sticking the scull in.

6706. I am not asking you about Crossness; I am asking you about the appearance which you have seen on the surface at Woolwich?—I am not able to say. I have not tried to land at Woolwich except at the pier; but I did try to land at Crossness and could not.

6707. But I understood you to give evidence as to Woolwich, and I want to know what it is that you have observed at Woolwich itself; do you say that the mud on the surface at Woolwich has much increased?—It has increased, decidedly.

6708. At Woolwich itself?—I think so.

6709. On which shore?—On the south shore, in the bight. By "south" I mean between the dockyard and the arsenal.

6710. And you have yourself seen an increase of mud in that part?—Yes.

6711. And black mud on the surface?—I believe so.

6712. But you must know?—You are speaking generally of the whole distance. I am sure that there is black mud at the bottom of Warren Lane.

6713. Where is that?—That is the boundary of the arsenal.

6714. With respect to North Woolwich, where the sewer discharges itself, is there any increase of mud there?—Between the gasworks and the Northern outfall there is an increase of mud.

6715. Is there any sewer at the gasworks?—I do not know.

6716. Is there any discharge of refuse matter there?—Probably there is; it is more than likely.

6717. Of course I do not put to you that the smells are the same; there are a variety of unpleasant smells, we know, in the river; but as you belong to these various sanitary boards, I may ask you what is the general condition of the health of your district?—A very low condition; there is a lot of low fever in Plumstead; there have been 173 cases of fever in the last 12 months.

6718. What is the sanitary condition of Woolwich?—Fair.

6719. Is it not the fact that the proportion of what we call preventible diseases, or those which are attributable to causes of infection, is extremely low in the Woolwich district?—Yes; that is because they ventilate their sewers.

6720. You have told us that you are not a scientific man, and I only want the fact and not the reasons. The proportion of typhoid fever, diarrhœa, diphtheria, and all that class of diseases is extremely low at Woolwich, is it not?—Yes.

6721. Is it not a fact that the district close to the river is even lower in its per-centage of these diseases than other parts of Woolwich?—I do not know. I have no means of telling that, because I am not aware that it is divided. It is divided into the arsenal district and the dockyard district. It is divided north and south, not east and west.

6722. I suppose your medical officer has reported to you from time to time?—We have no medical officer.

6723. How is that?—I do not know.

6724. Is there any medical officer at Plumstead?—Yes.

6725. How far is Plumstead from the river, where these cases of low fever occur?—It is bounded by the river on the north to a much greater extent than Woolwich is.

6726. We have had a gentleman here who has told us that these cases of fever occur at a distance of even three or four miles from the river; have you localised these cases of low fever?—Yes. I think you can localise them within a mile and a half of the river.

6727. When you speak of low fever, do you speak of ague and malarious fever?—There is no ague now. It used to be a very famous place for ague, but since the railway has been constructed the ague has ceased. There is a railway cutting which ventilates the marsh.

6728. Do you say that you have had any reports from your medical officers that typhoid fever, diarrhœa, and diphtheria, or any of that class of disease, was occurring near the river at Plumstead?—On the side of the town nearest the river there is a great deal of it; but between it and the river there is a place called Plumstead Marshes. After you have passed the arsenal the town of Plumstead lies at the foot of the hill, and rises up the hill.

6729. How far is that from the river at the nearest point?—The nearest point would be at Griffin Manor Way, about three-quarters of a mile from the river.

6730. Therefore, any emanation from the river would have to pass over three-quarters of a mile before it came to Plumstead?—Yes, beyond the Arsenal.

6731. And you have had no return made to you as to cases of disease at Woolwich, occurring near to, or far from, the river?—Not as distinct from the general health of the town.

6732. And the general health, you have told me, is extremely good?—It is fair.

The witness withdrew.

Mr. WILLIAM COLLINGRIDGE, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb., recalled; cross-examined by Mr. BIDDER.

*Mr. W. Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

6733. You said in your former evidence that you had watched the outfalls on a certain occasion, and that the sewage was running out on what apparently was the flood. Is it not the fact that you had the outfalls watched for a very considerable time with the result that the sewage was always, on those occasions, discharged on the ebb?—No, that is distinctly not the fact.

6734. (*Chairman.*) There are two questions put to you, one of which is, Did you have the river watched for a considerable time?—No, I did not.

6735. (*Mr. Bidder.*) I accept your statement that you have had it watched on these particular occasions; but is it not the fact that you had the outfalls watched repeatedly, and for a considerable time, and have observed no discharge upon the flood?—No, it is not the case that I have had it watched repeatedly and for considerable periods.

6736. (*Chairman.*) You have had it watched upon other occasions besides those which you mentioned to us the other day?—The outfalls were watched upon one other occasion, and that, I think, was in 1880.

6737. (*Mr. Bidder.*) I shall come to that in the course of your reports I think. I will take you through the reports in their order, as I have, since the last meeting of the Commission, had an opportunity of reading them and seeing what is in them. I believe the first report that you made, or the first that we have been furnished with, is one for the half year ending 30th June 1880?—That is so.

6738. I am not going, of course, through that report, but I see that there are one or two matters referred to there. First you report, at page 12, upon the school ships. Now the school ships, as we all know, are permanently moored in the river, and all of them below the outfalls, are they not?—All, with one exception, the "Warspite."

6739. Where is the "Warspite"?—She is moored off Charlton.

6740. Of the others, one is off Purfleet, I think?—One is off Purfleet; that is the "Cornwall."

6741. Two, I think, are off Greenhithe?—At Greenhithe there are two vessels, the "Arethusa" and the "Chichester." The "Chichester" is not used as a training ship, but she was until about two years since, I think. There are other vessels below.

6742. I see you report that, "In two only of the "seven training ships, containing altogether between "2,000 and 3,000 young subjects, were any cases of "zymotic disease observed in the course of the half "year; and the sanitary condition of most of these "establishments remained very satisfactory during "this period." May I take it that the two cases you refer to are those which follow?—Those are the two cases.

6743. First you speak of a boy affected with scarlet fever on the "Shaftesbury"; it is not suggested, I think, that that had anything to do with the condition of the river?—No.

6744. And then on the next page you mention that on the "Arethusa," notwithstanding the very favourable sanitary condition of the ship, there were several isolated cases of typhoid fever?—Yes.

6745. It is the fact, is it not, that although the "Arethusa" and the "Chichester" lie almost side by side off Greenhithe, for some reason or other the "Arethusa," for a considerable time, appeared more liable to disease than the "Chichester"?—That is so.

6746. And you yourself came to the conclusion that there was something peculiar to the vessel, or to some of her arrangements, that caused the disease?—I did.

6747. Then you speak of a report of the Local Government Board on what was supposed to be enteric fever occurring on the "Cornwall." I want to ask you, in order to identify it, whether that is the attack which was the subject of the subsequent report which we have already had put before the Commission, in which it was stated by Dr. Power that it was traced ultimately to trichinosis?—No, this was an outbreak in 1875, on which an inquiry was commenced by Mr. Netten Radcliffe.

6748. But you say, "As this outbreak, and also a previous one in 1875"?—I beg your pardon, it is so.

6749. Then I am right that that is the trichinosis outbreak?—Yes.

6750. Then you refer to something that occurred in 1875, in the time of Mr. Leach. If you turn to the latter part of your report, I find what purport to be extracts from the monthly report of the medical officer for July 1880. I asked you just now whether you had not had the outfalls watched on other occasions, with the result that there was nothing irregular in the discharge. You have described the condition of the water as being unsatisfactory, and you say that it had slate-coloured patches in it, and that you have taken samples of water from the darker patches, which were simply sewage, more or less diluted. I suppose those are the same patches that have been mentioned by you and other witnesses in evidence here. Have you the analyses of those samples which showed them to be more or less diluted sewage?—No; I said last Tuesday that they were not analysed.

6751. Then is that a mere general statement, not intended as representing the result of analysis?—It is not the result of analysis.

6752. Then you say that the river was so bad, that had the hot weather continued the consequences might have been very serious; that the source of the pollution then became a matter for serious consideration; that some portion of it doubtless was poured into the river from the metropolitan outfalls; and that, if the sluices were open during flood, this quantity might be very considerable. Then you go on to say that, with a view to obtain definite and exact information upon this point, you communicated with the Commissioner of Police, and that through his courtesy you had been able to have the outfalls watched day and night. "Up to the present time, however, the reports have "been satisfactory, proving the discharge to be "effected only during the first part of the ebb"?—The question was whether a repeated watch for a long period had been kept at the outfalls; I say, distinctly, no.

6753. You told me just now that you had not had them watched previously?—I said on one other occasion, and this was the occasion to which I refer, when it says distinctly that watch was kept for more than a week.

6754. At any rate, on that other occasion, as you say in this report, the result was thoroughly satisfactory?—Certainly.

6755. Do you not think it would have been fairer to mention that?

(*Chairman.*) That is hardly the question.

6756. (*Mr. Bidder to the witness.*) You mention also that there are "a large number of small outlets "which empty themselves into the river between the "great outfalls and Teddington Lock"; and you add, that in spite of all legislation upon the subject an enormous quantity of fœcal matter is still allowed to run into the river, and convert what would otherwise be a tolerably clear stream into a foul sewer. May I take it as the result of your observation at that time that enormous quantities of fœcal matter were running into the river from sources other than the outfalls of the Metropolitan Board?—That sentence clearly refers to the enormous amount of fœcal matter discharged into the river from all outfalls, including the great outfalls and those others mentioned.

6757. I am not asking you what this sentence means; but I ask you whether, as a matter of fact, your observation at that time did not lead you to the conclusion that enormous quantities of fœcal matter were being discharged into the river from sources other than the outfalls of the Metropolitan Board?—Certainly the quantity was large.

6758. And you appended a list, I see, of foul outfalls to that?—Yes.

6759. Is it the fact, as shown on that list, that several places upon the river not only have important foul outfalls, but that they were increasing in number in 1880? Take, for instance, Brentford: "Brentford "is one of the chief offenders of the upper river. "Nearly the whole of the sewage of the district is "emptied into the Thames. In 1878 there were "only 15 foul outfalls; there are now no less than

*Mr. W. Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

12 Dec. 1882.

"25"?—That is so, certainly. It does not follow that 25 is an increase on 15. It merely follows that 25 were observed on that occasion, and only 15 on a former occasion, because many of those openings and drains, some small and some large, are only uncovered at certain states of the tide.

6760. You made that reservation with reference to Chelsea,—that there was an apparent increase, but you did not know whether it was real,—but not with regard to Brentford?—It would certainly apply to all.

6761. Then you say, "Fulham is the upper boun- "dary of the Metropolitan Main Drainage Scheme. "In spite of this, however, it has added two foul "outfalls since 1878"?—There it must be clear that they were added.

6762. You mention again at Whitechapel three additional foul outfalls; at Limehouse the removal of nine, and four additional; at Poplar a large increase of 20, although several closets have been removed; and in both Poplar and West Ham you say that the apparent large increase is due to the fact that upon the last occasion Bow Creek was not included in the district upon which, you say, you reported in June last. Have you that report upon the West Ham outfall?—I have not.

6763. Can you get it and produce it before the Commission?—Yes; it was a letter.

6764. You would have no difficulty in producing it?—No difficulty whatever. (*See Appendix B.S.*)

6765. Meanwhile, is it the fact that you have from the West Ham outfall a very considerable and very offensive discharge of sewage?—It is.

6766. Am I right in this: that the West Ham outfall discharges into the River Lea just at Blackwall?—Yes, at some little distance up the river; it is a little way up Bow Creek.

6767. Can you tell the Commission what proportion of the sewage discharges at that outfall?—No, I cannot.

6768. You also say that there is a very large outfall conveying sewage from a number of houses on the banks; is that also in the River Lea?—That is in Bow Creek.

6769. Does that outfall still exist?—Generally speaking, undoubtedly.

6770. Then the next thing is of some importance, as to a matter about which there has been some dispute here. You say that Woolwich has made no change; that it has only two outfalls, one of which is a large and very foul outfall at the Beckton Gasworks?—That refers to North Woolwich.

6771. Is it the fact that there is up to the present time a large and very foul outfall at the Beckton Gasworks?—I cannot say that it is so up to the present time.

6772. Was it so the last time you were there?—The last time I saw it was, I think, fully two months ago.

6773. Then according to all your observations it exists?—Yes, the outfall exists.

6774. And it is large and very foul?—It was not so on the last occasion, and I have heard no complaint of it in the last 18 months.

6775. Have you had very frequent complaints from people engaged in the coasting trade, whose vessels were lying there?—I think about two years ago I had a great many complaints.

6776. What was the nature of the offensive matter that came from that outfall?—There was a certain amount of sewage; I think it was storm-water, and there was also a certain amount of tarry matter with it, gas liquor; but I have had no complaints from Beckton for the last 18 months or two years.

6777. Then you go, I see, to the south side of the river, and beginning up at Richmond you state that Richmond still empties the greater part of its sewage into the river; that when last inspected there were 13 foul outfalls, and now there are 19. Does that condition of things still exist?—I cannot speak from memory; but there is a later report upon the same subject, which would show any change. Speaking from memory, I suppose it is so.

6778. Nothing has been done, so far as you know, to divert the Richmond sewage?—No, I think not.

6779. Then Barnes is the next place which you mention which had added several fresh outfalls, and which is now credited with 32; does that remain in the same condition?—I believe so.

6780. Then you mention Rotherhithe as having removed two outfalls, but having 21 still remaining?—Yes, but those are all very small indeed.

(*Chairman.*) The issue that we have to try is the state of the sewage at the present time. The question is whether there is not now a great deal of sewage pouring into the river; but whether it poured in in 1880 is not very material.

6781. (*Mr. Bidder.*) You will remember the mass of evidence that has been called to show what was the state of the river in 1880. I should be very happy if the Commission say, We will exclude all evidence as regards the condition of the river in 1880; but I do not think my learned friends would be satisfied. (*To the witness.*) Then I see you point out that from Greenwich to Gravesend there have been no changes, and that the number of outfalls is still very large. May I take it that that is true at the present time?—Yes.

6782. And you sum up by saying that there were no less than 384 foul outfalls in your district at that time. Are you able to give the Commission the figure, if that figure has been altered, at the present moment, or shall I come to it in a later report?—You will come to it in a later report.

6783. Is it the case also that a very considerable and important contribution to the sewage matter of the Thames is made by the floating population?—Undoubtedly, a large amount.

6784. What do you estimate that floating population at?—It has been estimated by Dr. Leach at from 15,000 to 20,000. I have no means of checking it, but I believe it is too large an estimate.

6785. Now I have one or two questions to ask you with reference to your next report, which has been put upon the notes, and that is the report which is dated the 5th of May. That, I take it, deals with the second half year of 1880?—Yes.

6786. In the paragraph on the "river" you repeat your former statement about the slate-coloured patches, and about the samples being simply sewage more or less diluted: may I take it that that also relates to the same samples and that there have been no analyses?—Yes.

6787. I find again in that report you state that the quantity of sewage poured into the river would be increased if the sluices at the outfalls were opened during the flow of the tide, and that you kept a watch on the stations for more than a week, day and night, but no definite proof could be obtained. That appears to be a second occasion on which you kept watch?—This, I believe, is the same report.

6788. The other was dated six months before. On page 30 of the notes there is a statement that you kept a watch on the outfall station for more than a week, day and night, and could get no definite proof of anything irregular being done?—This is the same report, word for word.

6789. The one that you had already printed in December?—Yes.

6790. That is the same occasion?—Exactly.

6791. I may take it, without reading the report, that you were of opinion at that time that the foul outfalls, and matters that I have already spoken to, were a very serious cause of fouling of the river?—I was of opinion that all the sewage discharged into the river was a very serious fouling of the river.

6792. With reference to what you mention on the next page, as to there being 30 tons of condemned fish, which were in an advanced stage of decomposition, which caused an intolerable stench, and so on, was that in craft moored on the river?—Yes, moored off Billingsgate.

6793. Was it your duty to go and inspect it?—Certainly if it was there.

6794. Have you any doubt that you did do so?—None whatever.

6795. You are quite sure that that was not the occasion on which you were unwell?—I am perfectly certain about it. This was in August.

6796. Now we come again to the reference to the school ships. I see you report that, with the exception of the "Arethusa" and the "Cornwall," the health of the school ships had been fairly good; and then you speak of one case of scarlatina and one of typhoid fever on the "Warspite"; you do not suggest, I presume, that that has any particular connexion with the river?—I think the next paragraph suggests that there is a possible connexion.

6797. You say, "The typhoid fever occurred at the "time when the state of the river was at its worst, "and though it is impossible to attribute it to this, "still, without doubt, this in itself was quite sufficient "to account for it." You did not consider yourself justified at the time in saying that the river was the cause?—Certainly not.

6798. I suppose in so large a community as you have in these training ships you could not expect entire immunity from occasional attacks of fever?—No.

6799. You speak of the renewal of typhoid on board the "Arethusa." Without reading long passages about it, may I take it that the result of your observation with regard to that was that in your judgment it was something which on that occasion also was specially attributable to the condition of the ship herself?—Yes.

6800. You point out that the "Chichester," lying close by her, was thoroughly healthy?—Yes.

6801. You mention an attack of typhoid on the "Cornwall," and several previous epidemics, and I see you there suggest that the "Cornwall" was affected by her position off Purfleet, and that the sewage had something to do with it, and that the germs of the typhoid were brought down from London by the sewers. Have you any evidence that there was, in fact, any epidemic of typhoid in London at that time?—I think there was a good deal of typhoid fever at that time, but I am not able to say so positively.

6802. You do not suggest in your report that there was any prevalence of typhoid in the metropolis?—There must always be a certain amount.

6803. I do not think there is anything further in that report which makes it necessary for me to ask you any question. Therefore I pass to the next report, which you presented on the 6th of October. By-the-bye, is it the fact that the ship used for small-pox patients was moved recently to the neighbourhood of the outfalls?—It has been moved down about a quarter of a mile down the river below the "Cornwall," but on the opposite shore.

6804. And that the health of the patients has been improved by the change?—I believe there are none on board at all, nor have there been since she was moved there.

6805. Are you sure of that?—I believe it is so.

6806. (*Chairman.*) Have the small-pox patients been moved on shore?—They were all moved before the vessel was taken down, and I am certain that there have been none on board since.

6807. (*Mr. Bidder.*) In the report to the 30th of June 1881, you report that the health of the training ships during the past six months had been exceptionally good, not one case of infectious disease having occurred on any of them, and you add that this is remarkable, as the number of boys on all those vessels averages about 750, and those all at a time of life at which are they most susceptible to the influence of zymotic disease?—That is so.

6808. May I take it, as the result of your observation, that, so far as the general health of the boys is concerned, they could not have been in a healthier position?—Certainly not, so far as the health of the boys is concerned, because they are completely isolated from the risk of infectious diseases. I merely speak so far as zymotic disease is concerned.

6809. And with the exception of these special outbreaks, which have been usually traced to special causes, the boys upon the training ships upon the river have enjoyed remarkably good health and immunity from disease?—During the last two years I think that is so.

6810. Your next report is a special report dated the 8th of December, and presented on the 15th of December. You go into certain questions of analysis of water, and it appears that some samples were taken and given by you to Professor Wanklyn to analyse, and you mention a discrepancy between the result obtained by yourself and the result obtained by Professor Wanklyn, which, I think, you have also explained in a note. May I take it that Professor Wanklyn's results are more in accordance with the usual method of estimating the impurities in water?—No.

6811. You have mentioned there how, beginning at Teddington, and taking samples, you traced the water gradually increasing in impurity as it received the sewage of riparian districts?—Yes.

6812. I infer that the result of your observations at that time was, that, coming down from Teddington, you found a distinct increase of impurity attributable to sewage poured in from the banks of the river on each side?—Partly, undoubtedly.

6813. Then you mention that the impurity became more marked at the metropolitan outfalls. It is asserted in the next paragraph that the worst specimen examined was one taken at Barking on the 23rd of November, when the tide was running down, and which was reported to contain about one-fifth of its volume of sewage. Was that specimen taken by yourself?—The sample was taken by myself.

6814. Was it taken in the line of the sewage?—It was taken just at the edge, between the line of sewage and the river water.

6815. How far was it from the outfall?—I should think about 300 or 400 yards from the outfall.

6816. Have you an analysis which shows it to be one-fifth sewage?—I have not; that is a quotation.

6817. From whom?—As I say, "which is reported to contain about one-fifth." If you refer to the end of the report it gives Professor Wanklyn's own remarks, and it is taken from that.

6818. Will you identify it with any of the analyses which are set out in the Appendix, and tell me which of them it is?—Yes; that will be sample No. 15.

6819. Are you quite certain as to the exact distance and position from the outfall at which you took that sample?—Yes: I say about 300 or 400 yards below the outfall.

6820. Then I see that the result of your observations at that time also showed that when you got as far as Tilbury the sewage had vanished and the river was pure?—Yes.

6821. You also express an opinion, judging, as you say, by the literature of the subject, that the condition of the Thames has much improved since the Metropolitan Board of Works have carried the sewage down to Barking and Crossness?—I think there is no question about it. I judge entirely from the literature. I had no previous knowledge of the Thames.

6822. (*Mr. Abernethy.*) To what part of the river do you refer?—I refer there simply to the upper part of the river.

6823. (*Mr. Bidder.*) You do not say so?—I do not say so. I was asked to what I referred.

6824. What do you mean by the "upper part"?—I mean that, judging from the literature of the subject, I am under the impression, and believe, that the condition of the river below is very much what the condition of the river was above before.

6825. Then there is nothing more, except that I see you have given in an Appendix the analyses of these samples; were they all taken by yourself?—Yes.

*Mr. W. Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

12 Dec. 1882.

6826. In the report for the half year ending the 31st of December 1881, on page 11, you mention a great nuisance in Limehouse Creek; is that special to Limehouse Creek?—It refers particularly to Limehouse Creek.

6827. You speak of a nuisance which was found to exist at that spot; did you trace that to the same source?—Yes; there was a great deal of vegetable matter floating on the surface of the water. That had collected at the edge of the creek, and for some reason or other, chiefly on account of the large number of barges blocking up the creek, it did not get away. There were, I think, two closets communicating with three houses at the head of the creek, and this caused a good deal of nuisance. Those closets were done away with, and the creek was cleaned out.

6828. The report of the 5th of October of this year is, of course, a report that has been produced since we have been before the Commission, and I think all I need notice there is that you have spoken, as the result of your observation, of the continued good health generally of the boys on board the training ships?—Yes.

6829. May I take it that you find also that the health of the crews of vessels frequenting the port is generally good?—I think the port certainly is a fairly healthy port. There are great complaints from crews coming up the river and passing the sewage outfalls; but, taking the whole of the port into consideration, I think it is certainly a fairly healthy port.

6830. With regard to these foul outfalls which you speak of in the passages I have referred to, do you find that where you have a foul outfall discharging on the banks of the river there you get a local nuisance?—Where you have an outfall discharging at some point below low-water mark, and where discharge goes on at low water, of course you have some amount of local nuisance.

6831. And, as a matter of observation, you have found that in a good many instances?—Yes, in a certain number of instances, undoubtedly.

6832. You gave a general description of the mud, but have you ever analyzed the mud?—No, I have not.

Re-examined by Mr. Lumley Smith.

6833. As I understand you, before you come to the outfalls at Barking and Crossness, there are between that point and Teddington outfalls which you call foul outfalls?—Yes.

6834. And to a certain extent they pollute the river?—Undoubtedly to a certain extent.

6835. A good many of those that you mention in your report are single waterclosets and small outfalls?—By far the greater proportion of the 369 are very small indeed; many of them refer to single closets.

6836. And it is not an outfall, necessarily in the sense of a sewer, that is referred to?—It is simply any opening or drain from which you get sewage pouring out at any time.

6837. There are, however, among them some outfalls which cause considerable pollution, are there not?—There are.

6838. Are there many of the large outfalls as distinguished from the small outfalls?—The large outfalls are very few in number. There is a large outfall at Richmond. There are lower a good many small outfalls, at Brentford, for example, but most of those have been done away with. Then at some few points on the river there are a number of small ones together.

6839. (*Chairman.*) How many large ones can you speak of?—There is one at Bow Creek, the West Ham outfall. There is one at North Woolwich, and one at Beckton; that is scarcely a large one, it is a large opening, but there is no large amount of sewage coming out of it. I think those are almost the only large outfalls. Of course there is the West Kent outfall; that is below the metropolitan outfalls.

6840. (*Mr. Bidder.*) Have you mentioned Barnes?—I do not know of any large outfall there.

6841. You have said in your report that it discharges all its sewage into the river?—Quite so, by a number of small outfalls.

6842. Could you give us the population which drains into the river through these outfalls?—In the case of the upper ones I think it would be almost impossible to give it.

6843. (*Chairman.*) Have you the information in your office?—No, I have not. At Richmond especially there are a very large number of cesspools.

(*Mr. Michael.*) We shall be able to give that information.

(*Mr. Lumley Smith.*) West Ham is in the jurisdiction of the Metropolitan Board of Works.

(*Mr. Michael.*) No, it is a local board, entirely irrespective of the Metropolitan Board of Works, though it adjoins it.

6844. (*Mr. Lumley Smith to the witness.*) Then there is the floating population?—Yes.

6845. Is the result that the water of the Thames is to a certain extent polluted before it meets the sewage which pours out from the Barking and Crossness outfalls?—Yes.

6846. The sewage that pours out from the Barking and Crossness outfalls is not diluted entirely by freshwater, but by a stream which is already to some extent polluted?—Yes, by sewage-polluted water.

6847. With regard to the training ships, two of them, I think, are at Charlton?—One is at Charlton.

6848. That is some little distance above the outfalls, is it not?—Yes; that is the "Warspite."

6849. The "Arethusa" and the "Chichester" are at Greenhithe, are they not?—Yes.

6850. That is a good way off, is it not?—Yes.

6851. Which is the one which is at Purfleet?—That is the "Cornwall."

6852. I see that in one of the reports from which my learned friend has been quoting with regard to the "Cornwall" you speak of the position of the "Cornwall" as being unfortunate, and you say: "It "seems that with this unfortunate history of repeated "outbreaks there must be something radically wrong, "and I am inclined to attribute much of the blame to "the position of the vessel. She lies off Purfleet in "a bight, and the stream during the ebb, after striking "the opposite point, sets directly into this bay. At "ebb the current carries down the great volume of "sewage from the metropolitan outfalls with it. This "can be seen occasionally as a dark line on the "water, while at all times evidences of sewage can be "found in the mud on the foreshore." You consider that the position of the "Cornwall" is unfortunate, having regard to the health of the boys?—I do. I think that the "Cornwall" is moored in a very unfortunate position with special regard to the outfalls of the metropolitan sewage. It is too near the outfalls, and it is at a point where the sewage is carried directly round the vessel.

6853. And you find in that vessel repeated outbreaks of illness?—Yes.

6854. Apart from the sewage, I understood you to say that the isolated condition of the boys on a training ship was favourable to health?—Undoubtedly, so far as infectious diseases are concerned.

6855. They run less risk of catching fever and other illnesses than they would on shore?—Certainly.

6856. That would be something countervailing any disadvantage arising from the sewage?—Yes.

6857. I do not know whether you have formed an opinion as to the effect of this sewage upon health?—It is impossible to see the state of the water, and to know that such a large amount of sewage is poured into it, without believing that the health of persons living on the water, or brought constantly on the shores of the river, must suffer from the effects. I think there can be no question about it.

Examined by the COMMISSION.

6858. (*Chairman.*) That is the inference that you would draw?—It is, certainly.

6859. But from your experience of the river as a medical man, is it, or is it not, a fact that you have found very little, if any, complaint of loss of health arising merely from the smell on the river from the sewage?—You get very many complaints; but the difficulty with regard to the river is that it is almost impossible to get statistics. You lose sight of people on the river directly anything occurs to them. The population of the river is constantly changing, and if a man is taken ill you lose sight of him altogether.

6860. From your experience, are you of opinion that the sewage in the river has been prejudicial to the health of the people on or near the river, or merely that it is uncomfortable to them?—I think, unquestionably, that it has a distinct influence upon health; it must have.

6861. But you infer that it must be so without being able to produce any particular instances?—I do not know that I can produce any particular evidence, except my own case.

6862. With respect to the amount of the sewage discharged from these 369 foul outfalls, has that sewage any appreciable effect upon the purity of the river above the outfalls?—It is an infinitesimal quantity compared with the quantity from the metropolitan outfalls. The majority of those 369 discharge an exceedingly small quantity. In the case of the few larger ones, of course it is possible to get the exact amount.

*Mr. W. Collingridge, M.A., M.D., M.R.C.S., S. Sc. Cert. Camb.*

12 Dec. 1882.

6863. (*Mr. Bidder.*) You cannot give the Commission the population that drains into these riparian drains, other than the metropolitan sewers. I suggest to you that it is 400,000 or 500,000 people?—I have no means of checking that.

(*Chairman.*) That there is such a population is likely enough; but whether it drains into the river is another question. That population could hardly drain through 369 insignificant outfalls.

(*Mr. Bidder.*) For instance, I may mention that the population draining through West Ham is over 100,000.

(*Chairman.*) But I expect you will find that that place is full of cesspools.

(*Mr. Balfour Browne.*) Dr. Collingridge himself pointed that out with regard to Richmond.

(*Chairman.*) I am speaking of Barking.

6864. (*Mr. Bidder to the witness.*) Do you suggest that cesspools exist in Richmond to any large extent?—Certainly. I know it as a fact.

The witness withdrew.

(*Mr. Bidder.*) It will be recollected that when Sir Joseph Bazalgette gave his preliminary evidence he was asked at questions 109 and 110 whether he could give the quantity of sewage discharged at the outfalls since the year 1878. It is on record up to 1878 and published. He said he could do it, but that it would take some time to get it out. We thought it right to provide every information we could for the Commission, and it has been now taken out, and I propose to hand in, so that it may go upon the notes, a statement of the discharge of the sewage from each of the outfalls for the years 1879, 1880, 1881, and the present year up to the 22nd of November last, in the case of Crossness, and up to the 24th in the case of Barking. Perhaps it may be convenient that I should add, in explanation of what may seem a spurious amount of fluctuation in the Table, that it is dependent to a certain extent upon the rainfall of the year, because a good deal of the rainfall gets into the sewers, and that is the reason why you find that there is no continuous growth.

*The following Table was handed in.*

5th December 1882.

DISCHARGE of SEWAGE from the BARKING and CROSSNESS OUTFALLS during the years 1879, 1880, 1881, and 1882, up to 22nd November for Crossness and 24th November for Barking.

| | | Gallons. |
|---|---|---|
| 1879: | Barking - - | 33,616,848,827 |
| | Crossness - - | 31,065,965,556 |
| | Together - | 64,682,814,383 |
| 1880: | Barking - - | 32,390,858,252 |
| | Crossness - - | 29,533,247,494 |
| | Together - | 61,924,105,746 |
| 1881: | Barking - - | 32,632,794,334 |
| | Crossness - - | 27,223,090,538 |
| | Together - - | 59,855,884,872 |
| 1882: | Barking to 24th Nov. - | 27,553,687,490 |
| | Crossness to 22nd Nov. | 21,043,864,091 |
| | Together - - | 48,597,551,581 |
| Totals: | Barking from 1st Jan. 1879 to 24th Nov. 1882 - - | 126,194,188,903 |
| | Crossness from 1st Jan. 1879 to 22nd Nov. 1882 - - | 108,866,167,679 |
| | Together - - | 235,060,356,582 |

Mr. JAMES MOORE MASON called in and examined by Mr. LUMLEY SMITH.

6865. You reside at East Greenwich, do you not?—Yes.

6866. I believe you are a member of the Greenwich District Board of Works?—That is so.

6867. And you are familiar with the drainage of Greenwich?—Yes.

6868. I see by the map that the main outfall sewer of the Board of Works passes from the Deptford pumping station through Greenwich?—That is so.

6869. And it passes along the Trafalgar and the Woolwich roads?—Yes.

6870. Is Greenwich drained into that sewer?—The whole of the Greenwich district is drained into it.

6871. That sewer has been in existence, I suppose, since 1864?—Yes, when the main drainage system was first constructed.

*Mr. J. M. Mason.*

6872. Was Greenwich then drained into it, or has it been joined since?—Greenwich was drained into it at the time.

6873. For some time did the system work well, as far as Greenwich was concerned?—So far as I know, it did; to the best of my belief, it did.

6874. For some years have you found it a matter for complaint?—Yes.

6875. At what seasons do you find matter for complaint?—Principally when there is a very heavy

*Mr. J. M. Mason.*

12 Dec. 1882.

rainfall the sewage increases in quantity. The large sewer is then incapable of holding the amount of sewage which comes into it.

6876. Does the sewage make its appearance in Greenwich?—The result is that it comes up into the lower basements of the houses in the neighbourhood, and in some instances it flows through the gullies or traps on the main road. I have seen it on one or two occasions; and also in the Greenwich Marshes I have known it to force up the manholes when they have been locked down.

(*Mr. Bidder.*) I must take the opinion of the Commission as to whether we are not now travelling entirely beyond the scope of this enquiry. The Commission is sitting to enquire into the system under which sewage is discharged into the Thames by the Metropolitan Board of Works, and whether any evil effects result therefrom. The matter which this witness is giving evidence about is the fact that, as he states, under certain conditions it does not discharge into the Thames, but comes into the streets. It may be a very serious and important complaint, but it is not one that we have to deal with here.

(*Chairman.*) He is only speaking of its getting into basements and through gullies, but perhaps eventually it gets into the Thames.

6877. (*Mr. Lumley Smith to the witness.*) What becomes of the sewage when it gets free from the sewers and makes its appearance in the houses?—I have known it run into the open ditches in Greenwich Marshes, and at low water to empty itself into the Thames, on those particular occasions especially when I spoke of the great volume of sewage running into the sewers and forcing up these manholes or man-traps, or whatever they are termed. I am not up in the technical matters.

6878. Then on those occasions it has got into the Thames at Greenwich?—Yes, at Blackwall Point most likely. There are several outfalls there, along that district.

6879. And that you say you have known at low water?—The open ditches discharge themselves at low water.

6880. Has that happened on more than one occasion?—Yes; I have known it on two or three occasions.

Cross-examined by Mr. Bidder.

6881. On two or three occasions in how many years; since the sewers were opened?—Since the sewers have been constructed, of course.

6882. You have known it on two or three occasions at Greenwich in all that time since 1864?—I have known it more particularly in the last 15 years. I have been a resident in Greenwich 15 years.

6883. How much sewage, on those occasions, got in that way into the river?—I cannot tell you. I am not prepared to say.

6884. Did you see any?—Yes.

6885. Did you see it discharged into the river?—I know for a fact that it discharged into the river.

6886. Where did you see it discharged into the river?—I know for a fact that it discharged itself into the ditches, and of necessity it went into the river.

6887. In any considerable quantity?—A considerable quantity. I could not tell you what quantity.

6888. Did you trace it into the ditches?—Yes; and I made a complaint to the Board of Works about it, because it interfered with my own business.

6889. Had it raised the level of the water in the ditches?—Yes, a great many feet.

6890. You have not many feet to come and go on in those marshes?—Yes, we have. I have seen the water at some times four feet higher than at other times.

6891. Was this an occasion of a very heavy rainfall?—Yes.

6892. How long ago was the last occasion when it happened?—I can only tell you from memory. To the best of my belief, it was certainly within the last three years.

6893. On one occasion when the rainfall was not only very heavy, but something almost unprecedented within so short a time?—The greater the rainfall, the greater the amount of sewage to discharge.

6894. That we know. But on this occasion was the amount of rainfall so enormous as to be the subject of considerable remark?—Yes.

6895. And of course all the ditches on the marsh lands were full of water?—Yes, they would be; but they empty themselves each tide.

6896. They were necessarily full until low water came, and then they got a chance of discharging themselves?—Yes.

6897. (*Chairman.*) The two or three occasions of which you speak were within what time?—Within the last four years, I should think, when that particular state of things occurred.

6898. (*Mr. Bidder.*) Is it the fact that the Metropolitan Board of Works are at the present time actually making a large additional sewer for the purpose of relieving that district, so that it will be impossible for such a thing to recur?—It is a fact that the Metropolitan Board of Works are making a new sewer in the Deptford district on the London side of the pumping station, to throw the water into the Thames.

6899. Will the effect of that sewer be to relieve the sewer through Greenwich?—I am quite willing to answer any question that I know about; but if I do not know it, I cannot answer.

6900. Does the course of that sewer run through Greenwich?—No, the one that they are constructing now runs through Deptford. Originally it came into the pumping station.

6901. Where does that sewer run from and to?—This new sewer that they are constructing now runs from the Lewisham district, and joins the old sewer at Deptford.

6902. (*Chairman.*) Has it joined it?—I am not quite sure whether it has at present; but it is intended to. It originally came into Deptford Creek; when there was a large overflow it ran into Deptford Creek.

6903. (*Mr. Bidder.*) Do you happen to know that the great mass of the water that came on the occasions you speak of, and increased the volume in the sewers, came from the Lewisham direction down the Ravensbourne?—No, it came from the pumping station at Deptford Creek, or the Ravensbourne on the Greenwich side.

6904. But the water did not come out of the pumping station; it must have come from somewhere else?—I am prepared to say that it did come from the pumping station.

6905. Are you aware that the object with which this sewer is being constructed is to relieve the sewers of that water which caused the overflow that you spoke of?—

6906. (*Chairman.*) Have the Metropolitan Board of Works told you that?—Yes.

(*Mr. Lumley Smith.*) I think the witness scarcely understood the question.

6907. (*Chairman to the witness.*) Mr. Bidder asked you whether the object of the Metropolitan Board of Works in making this sewer was to have a certain effect, and I asked you whether you knew anything about it?—It is made to relieve the Lewisham district.

6908. How do you know that?—It has been stated so on our Board.

6909. Who stated it?—The officers of the Board.

6910. (*Mr. Bidder.*) It is an official communication with the Metropolitan Board of Works. Being a member of the Board, do you not know that it is in consequence of your Board complaining to the Metropolitan Board of Works of these things that have happened that this sewer is being made?—Just so.

(*Chairman*). That confirms the story about there being this overflow.

Re-examined by Mr. Lumley Smith.

6911. Deptford is where the storm overflow is, is it not?—It is.

6912. You told us that a great deal of the water came from Deptford Creek?—It is a mistake if you understood me so. I did not intend to convey that impression. The pumping station is insufficient for taking away the whole of the sewage that comes into it; there are five or six sewers that run into the pumping station.

(*Chairman.*) If I am not mistaken, Sir Joseph Bazalgette himself mentioned something about this very matter, and if we have the high authority of Sir Joseph Bazalgette, what do we want with any such authority as this witness?

(*Mr. Lumley Smith.*) Merely to show that in cases of storms the system gets overpowered.

(*Witness.*) Quite so; that is just the point.

*Mr. J. M. Mason.*

12 Dec. 1882.

The witness withdrew.

Mr. George Robert Mason called in and examined by Mr. Balfour Browne.

6913. I believe you happen to be a brother of the last witness?—Yes.

6914. Where do you live?—Lower Road, Deptford.

6915. And I think you are a member of the Deptford and Greenwich District Board of Works?—I am.

6916. And you have taken some interest at the meetings of that Board with reference to the question of sewage in your district, have you not?—Yes, I have a little.

6917. What have you reason to complain of in the Deptford district with reference to overflow?—I have some houses in the parish of Deptford, near to the Thames, and the tenants complain very often there of the stench from the river, and it keeps continually getting worse.

6918. Have you any particular complaint to make with reference to the overflow of the sewers within the Deptford district?—Though I live at Deptford, my brother and I—not the last witness—represent the firm of G. and H. Mason, Market Gardeners, of East Greenwich, and on some occasions I have known the sewer that exists in Greenwich Marshes to overflow after a heavy rain, and a large quantity of sewage to be emitted. I recollect, on one occasion in particular, the force of water was so great that it blew the tops off the manholes.

6919. Where did the sewage get to after it burst out of the sewers?—It came into the roadway, and from there it ran into the open ditches.

6920. And from thence?—From thence it went into the Thames.

6921. Was that upon more than one occasion?—Yes.

6922. Do you know anything about the Deptford storm outfall?—I know where it is. I pass over Deptford Creek every day, and sometimes twice a day. I was a fortnight back at the railway wharf buying some clover, and my attention was then drawn by the man on the wharf, who knew me to be a member of the Board of Works, to an accumulation of garbage, I may say, that came from the sewer.

6923. Was that near the outfall?—Yes, within 200 yards, I should think.

6924. Was the accumulation large or small?—I should think that there would be quite a cart-load of floating sewage, as it were. It laid in a kind of dock where Mr. May, the proprietor of the railway wharf, unloads his barges, on the ways where the barges lie.

6925. Can you tell the Commission whether there has been any damage caused to the barges in Deptford Creek by reason of the sewage?—I am not quite clear upon that point, but I believe there has.

*Mr. G. R. Mason.*

Cross-examined by Mr. Bidder.

6926. Are you also a member of the Local Board?—Yes.

6927. On one or two occasions you say there were these overflows?—Yes.

6928. Is it not the fact that your Board complained to the Metropolitan Board of Works?—I believe they did, more than once.

6929. And in consequence of those complaints the relief sewers were ordered?—Not to my knowledge.

6930. You say that certain garbage was pointed out to you by a man on the wharf?—Yes.

6931. Do you know where it came from, of your own knowledge?—He drew my attention to it, and told me it came there. He is manager of the wharf.

6932. Is it the fact that there are foul outfalls in Deptford Creek?—I am not conversant with the whole of the Creek. There was a drain running through a yard into the Creek, but I believe that has been remedied. There is an outfall from the sewer in Church Street, Deptford.

6933. That is the storm outfall?—Yes, but sewage comes as well.

6934. Are there not other outfalls quite distinct from the outfall in Deptford Creek?—Not to my knowledge.

6935. Have you examined it?—No.

Re-examined by Mr. Balfour Browne.

6936. But I understand you to say that from that storm outfall sewage comes?—It must follow that, if the storm water comes through the main sewer, the sewage must come with it.

The witness withdrew.

Adjourned to to-morrow at half past 12 o'clock.

# THIRTEENTH DAY.

## Wednesday, 13th December 1882.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

COLONEL C. B. EWART, C.B., R.E.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary.*

(*Mr. Lumley Smith.*) I am going now, with the permission of the Commission, to give some evidence about the rainfall; and to make that intelligible I would remind you of the evidence given by Sir Joseph Bazalgette on the first day of this inquiry. In the first day's evidence, at question 9, you will find that Sir Joseph Bazalgette stated, that in preparing the present system of sewers it was found from tables of rainfall that there were only from 14 to 21 days in the year on which the rainfall exceeded the rate of a quarter of an inch in 24 hours. The result is that on occasions of storms, when the sewers would carry off the storm water, the sewage goes direct into the Thames. We are informed that the rain that falls exceeds what I may call the prescribed rate on many more days than the number stated by Sir Joseph Bazalgette, so that the sewage would go direct into the Thames on many more days than was anticipated.

MR. GEORGE JAMES SYMONS, F.R.S., is called in, and examined by MR. LUMLEY SMITH.

*Mr. G. J. Symons, F.R.S.*

13 Dec. 1882.

6937. I believe you are a Fellow of the Royal Society?—I am.

6938. And you are, I think, a Past President of the Meteorological Society?—I am Past President, and I am now Secretary.

6939. You are the editor of a publication on British Rainfall, are you not?—Yes, I receive the returns from rather more than 2,000 stations throughout the kingdom.

6940. I think that for many years you have devoted your attention to the distribution of rain?—Almost exclusively from 1860 to the present time.

6941. I will take you first of all to the fall of rain in the metropolis. I believe you are informed of the evidence that has been given by Sir Joseph Bazalgette, as to the sewers being so constituted as to take the sewage and a quantity of rain equal to a quarter of an inch in the 24 hours?—Yes, or, as Sir Joseph Bazalgette put it, $\frac{1}{100}$th of an inch per hour.

6942. Have you prepared some tables, or are you able to tell us the result of your investigations as to the number of days on which rain exceeding that amount has fallen during the last two years?—I can go rather further than that. With the permission of the Commission I should like to offer a little information upon the point. Until a comparatively recent date rain gauges have been used which were only capable of giving the total fall during the 24 hours. With the exception of a gauge which exists at the Royal Observatory at Greenwich, there was not in the metropolitan district, or anywhere near to it, any means of determining the distribution of the rainfall over the 24 hours; that is to say, whether it all fell in two or three hours, or whether it was distributed over the 24 hours. Since about 1875 there have been gauges constructed which are self-recording, writing down the quantity minute by minute as it falls. Up to the present time I only know of four such gauges in the vicinity of the metropolis. There is the one at the Greenwich Observatory, to which I have already alluded, and which, being at a height of about 50 feet above the ground, collects less than the true quantity. It is a well known fact that rain gauges on roofs or elevated buildings catch too little. For that reason the Greenwich observations are not altogether available, and moreover, up to the present time they have not been published. There is another self-recording gauge kept by myself in the north of London, at Camden Square, which has been at work for about two years; but the records have been somewhat interrupted by the clock-adjustment not being perfect, and the observations have not been discussed. It could be done if it were desired. Another gauge is kept at Croydon by Mr. Baldwin Latham, and part of the results of that have already been published in one of my volumes. I think it might be as well if I were to put that in at once. I will place one copy before the Chairman (*handing in a book*). This is a communication by Mr. Latham published by me 18 months ago. Mr. Latham will, of course, subsequently be examined, and therefore you can receive it from him if you prefer it.

6943. (*Chairman.*) He will verify that if you will give us the result of your own observations?—I will come to that directly. I have now dealt with three of the gauges. The fourth one is at the Kew Observatory; that is under the Meteorological Office, which is a Government Department. The observations have been printed *in extenso*, and have been published, and are consequently accessible to any one. Those observations I have carefully discussed; but before taking out any of the values I thought carefully over what had been said as to the rate of a quarter of an inch per diem, and I rather gathered that it was possible that during certain hours of the 24, the amount of sewage going through the sewers was less than it was at others, and that possibly sometimes a greater amount than $\frac{1}{100}$th of an inch per hour might pass down the sewers. Consequently, I thought that instead of taking $\frac{1}{100}$th it would be fair to take perhaps $\frac{2}{100}$ths; that is to say, doubling the quantity suggested by Sir Joseph Bazalgette. Then there is another thing which is evident, namely, that in extremely dry weather, and under certain conditions, all the rain would not get into the sewers; and therefore that if you have $\frac{1}{100}$th of an inch falling, it does not follow that you have $\frac{1}{100}$th of an inch of rain in the sewers. For that reason I proposed further to limit it by assuming that only half the rain which fell got into the sewers. That involves a further doubling of the quantity, raising the minimum amount from $\frac{1}{100}$th of an inch first to $\frac{2}{100}$ths on the score of extra capacity in the sewers, and secondly, doubling it because of the possibility of all the rain not getting into the sewers. For that reason I took $\frac{4}{100}$ths of an inch per hour, and I carried out that investigation back for four years. The work is very heavy, and I have only four years done, and as the four years give very nearly the same results, it does not seem worth while to carry it much further. I start with the year 1880, which is the last year which has been published, 1881 and 1882 are not published. I have the tables *in extenso*, and I propose to hand them in. The tables contain the hourly rainfall at the Kew Observatory on days on which the rate of fall reached or exceeded one inch per diem; practically it is ·96 in., because ·04 in. multiplied by 24 gives ·96 in.; but it may be taken at one inch. Without going through the whole of the details, I may say that the abstract shows that the total number of days with falls of $\frac{4}{100}$ths of an inch per hour, or upwards, was in the year 1880, 83; in the year 1879, 95; in the year

1878, 82; and in the year 1877, 104. The average for those four years is, therefore, exactly 91. In looking through these figures I was struck with the fact that, instead of the ·01 in. per hour being a rarity, there were a great many instances of ten times that quantity, or ·1 in. per hour. I therefore took out the total number of days with falls of ·1 in. per hour or upwards, and those numbers are, for the year 1880, 41; for the year 1879, 37; for the year 1878, 38; and for the year 1877, 35; the average being 38. (*The following tables were handed in*).

ABSTRACT of the Records of the hourly fall of Rain at Kew Observatory, 1877–80.

| Years. | Total No. of Days with Falls of ·04 in. per hour or upwards. | Total No. of Days with Falls of ·10 in. per hour or upwards. |
|---|---|---|
| 1880 | 83 | 41 |
| 1879 | 95 | 37 |
| 1878 | 82 | 38 |
| 1877 | 104 | 35 |
| Average | 91 | 38 |

HOURLY RAINFALL at KEW OBSERVATORY on DAYS on which the RATE of FALL reached or exceeded (0·96 in.) one Inch per Diem.

| — | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | NOON. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | MIDT. |
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| 1880. Jan. | 14 | --- | --- | --- | --- | --- | ·105 | --- | --- | --- | --- | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| ,, | 16 | --- | --- | Melted snow and rain | | | | | --- | --- | ·060 | ·020 | ·035 | ·015 | ·025 | ·020 | ·015 | ·015 | ·020 | ·010 | ·005 | ·010 | ·005 | – | ·025 |
| Feb. | 7 | – | ·020 | ·010 | ·020 | ·010 | – | – | – | – | ·015 | – | – | ·035 | ·015 | ·015 | – | ·015 | | – | ·005 | ·005 | ·010 | ·005 | ·045 |
| ,, | 8 | ·075 | – | ·030 | ·075 | ·045 | ·005 | – | ·020 | – | – | – | – | – | – | ·015 | – | ·010 | ·005 | – | – | – | – | – | – |
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| ,, | 23 | – | ·055 | ·070 | ·020 | – | – | – | | – | – | – | – | – | – | – | | – | – | ·010 | ·030 | – | – | – | – |
| Mar. | 3 | – | ·080 | ·025 | ·095 | – | – | – | | – | – | – | – | – | – | – | | – | – | – | – | – | – | – | – |
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| ,, | 31 | – | – | – | – | – | – | – | – | – | – | – | – | ·005 | ·030 | ·015 | ·050 | ·010 | ·015 | ·015 | ·025 | ·010 | ·050 | – | – |
| April | 1 | – | – | ·015 | ·045 | – | – | – | | | – | – | – | | | – | – | – | – | – | – | – | – | – | – |
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| ,, | 13 | --- | --- | --- | --- | ·005 | --- | --- | --- | --- | --- | – | – | – | – | – | – | – | – | – | – | – | Funnel choked. | | |
| ,, | 14 | --- | --- | --- | Total for 13 hours = | | ·155 | --- | | | --- | – | – | ·020 | ·080 | ·115 | ·075 | ·060 | ·015 | – | – | ·010 | – | – | – |
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| ,, | 20 | – | ·005 | ·075 | ·050 | ·050 | – | – | – | – | – | – | – | – | – | – | ·120 | – | | | – | – | – | – | – |
| May | 31 | – | – | – | – | – | – | – | – | – | – | ·015 | ·045 | ·015 | ·045 | ·035 | ·025 | ·045 | – | – | – | – | – | – | – |
| June | 4 | ·040 | ·030 | ·020 | ·005 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
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| July | 1 | – | – | – | – | – | – | – | ·095 | – | – | – | ·260 | ·075 | ·120 | ·015 | – | – | – | – | – | – | – | – | – |
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| Aug. | 2 | – | – | – | – | – | – | – | – | – | ·035 | ·080 | ·115 | ·025 | – | – | – | – | – | – | – | – | – | – | ·010 |
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Hourly Rainfall at Kew Observatory, &c.—*continued.*

*Mr. G. J. Symons, F.R.S.*

13 Dec. 1882.

| — | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | NOON. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | MIDT. |
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| Sept. | 6 | – | – | – | – | – | – | – | – | – | – | – | – | – | ·015 | – | ·010 | ·060 | ·065 | ·100 | ·275 | ·300 | ·135 | ·190 | ·275 |
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| ,, | 20 | ·030 | – | – | – | Melted snow and rain = | | | | | ·605 | ·015 | ·020 | ·005 | ·010 | ·005 | – | – | – | – | – | – | – | – | – |
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| Nov. | 8 | – | ·005 | ·030 | ·050 | ·015 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
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| Dec. | 14 | – | – | – | – | – | – | ·065 | ·005 | ·015 | ·015 | – | – | – | ·010 | ·015 | ·015 | ·030 | ·005 | ·005 | – | – | ·005 | ·005 | ·005 |
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| ,, | 30 | --- | --- | --- | Melted snow = | | ·305 | --- | --- | --- | --- | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| 1879. | | | | | | | | | | | | | | | | | | | | | | | | | |
| Jan. | 1 | – | – | – | – | – | – | – | – | – | – | – | – | – | ·005 | ·040 | ·045 | ·130 | ·145 | ·165 | ·130 | ·070 | ·040 | ·015 | ·015 |
| ,, | 2 | – | – | – | – | – | Total to 10 a.m. = | | | | ·230 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| ,, | 3 | – | – | ·075 | ·080 | ·110 | ·120 | ·125 | ·100 | ·030 | ·010 | ·025 | ·005 | ·005 | – | – | – | – | ·005 | ·010 | ·005 | – | ·005 | – | – |
| ,, | 12 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | Melted snow = | | | 60 | – | – | – |
| ,, | 14 | – | – | – | – | – | – | – | – | ·010 | – | – | – | ·005 | ·015 | ·045 | ·055 | ·030 | ·050 | ·030 | ·015 | ·005 | – | – | ·055 |
| ,, | 18 | – | – | – | – | – | – | Melted snow = | | | ·300 | – | – | – | – | – | – | – | Melted snow = | | | ·270 | – | – | – |
| Feb. | 2 | – | – | – | – | – | Snow at 10 a.m. = | | | | ·185 | – | – | ·005 | ·010 | ·005 | – | – | ·010 | ·005 | – | – | – | – | – |
| ,, | 7 | – | – | – | – | – | – | – | – | – | ·090 | ·020 | ·030 | ·005 | ·010 | – | – | – | – | – | – | – | – | ·010 | ·005 |
| ,, | 9 | ·075 | ·060 | ·025 | ·065 | ·040 | ·005 | – | – | – | – | – | – | – | – | – | ·015 | ·015 | ·030 | ·015 | ·005 | – | – | – | – |
| ,, | 10 | – | – | – | – | – | – | – | – | ·030 | – | ·200 | ·050 | ·070 | ·130 | ·020 | – | – | – | ·005 | ·005 | – | ·015 | ·060 | ·085 |
| ,, | 11 | ·045 | ·020 | – | – | – | – | – | – | – | – | – | – | ·005 | ·010 | – | – | ·005 | – | – | – | – | – | ·010 | ·015 |
| ,, | 14 | ·020 | ·045 | ·005 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| ,, | 16 | – | ·035 | ·115 | ·040 | ·025 | – | – | – | – | – | – | – | – | ·005 | ·010 | ·005 | ·035 | ·045 | – | – | – | – | – | – |
| ,, | 19 | ·005 | ·005 | – | – | – | – | – | ·010 | ·010 | – | – | – | – | – | – | – | – | – | – | ·065 | ·045 | ·015 | – | – |
| ,, | 20 | ·005 | ·050 | – | – | – | ·030 | ·015 | – | ·010 | – | – | – | – | --- | --- | --- | --- | --- | Snowing | | --- | --- | --- | --- |
| ,, | 21 | – | – | – | – | Melted snow at 10 a.m. = | | | | | ·890 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
| ,, | 23 | – | – | – | – | – | – | – | – | – | – | – | – | ·030 | ·040 | ·010 | – | – | – | – | – | – | – | – | – |
| ,, | 27 | – | – | – | – | Melted snow at 10 a.m. = | | | | | ·055 | – | – | – | – | ·010 | ·015 | ·020 | ·005 | – | – | – | – | – | – |
| ,, | 28 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ·015 | ·035 | ·055 | ·055 |

Hourly Rainfall at Kew Observatory, &c.—*continued.*

| — | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | NOON. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | MIDT. |
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| 1879. | | | | | | | | | | | | | | | | | | | | | | | | | |
| Mar. | 18 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ·075 |
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| „ | 26 | – | – | – | Melted snow at 10 a.m. = | | | | | ·040 | – | – | ·005 | ·005 | ·010 | – | – | – | – | – | – | – | – | – | – |
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| Apr. | 7 | ·045 | ·035 | ·040 | ·055 | ·085 | ·010 | ·005 | ·010 | – | – | – | – | – | – | – | – | – | – | – | ·065 | ·035 | ·010 | ·060 | ·03 |
| „ | 9 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ·020 | ·125 | ·155 |
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| May | 5 | – | – | – | – | – | – | – | – | – | – | --- | --- | --- | --- | --- | Funnel choked | | | | | --- | --- | --- | --- |
| „ | 6 | --- | --- | --- | --- | --- | Total for 24 hours = | | | | ·200 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
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| „ | 28 | ·020 | ·005 | ·075 | ·025 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ·010 | ·330 | ·100 | ·220 | ·300 |
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| June | 1 | – | – | – | – | – | – | – | – | ·010 | – | – | – | – | – | – | – | ·015 | ·130 | ·270 | – | – | – | – | – |
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| July | 1 | – | ·005 | – | – | ·005 | ·020 | ·030 | ·045 | ·110 | ·145 | ·105 | ·070 | ·010 | – | – | ·005 | – | – | – | – | – | – | – | – |
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| „ | 4 | – | – | – | – | – | – | – | – | – | – | – | ·020 | – | – | – | – | ·070 | – | – | – | – | – | – | – |
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| „ | 7 | ·045 | ·040 | – | ·015 | ·015 | ·005 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
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| „ | 21 | – | – | – | – | – | – | – | – | ·010 | ·005 | – | – | – | – | – | – | – | ·015 | – | – | ·025 | ·040 | ·045 | ·050 |
| „ | 31 | – | – | – | – | – | – | – | ·010 | – | ·040 | --- | -- | --- | --- | --- | --- | Funnel choked | | | | --- | -- | | |
| Aug. | 1 | – | Total for 24 hours ending 10 a.m. = | | | | | | | | ·140 | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
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Hourly Rainfall at Kew Observatory, &c.—*continued.*

*M. G. J. Symons, F.R.S.*

13 Dec. 1882.

| — | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | NOON. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | MIDT. |
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| 1879. | | | | | | | | | | | | | | | | | | | | | | | | | |
| Aug. | 5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | ·015 | ·055 | ·030 | ·010 | – | – | – |
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| Sept. | 9 | – | – | ·020 | – | ·005 | ·005 | – | – | – | – | – | – | ·020 | – | – | – | – | – | ·080 | – | – | – | – | – |
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| Dec. | 6 | --- | --- | --- | | Melted snow = | | ·080 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – |
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Hourly Rainfall at Kew Observatory, &c.—*continued.*



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| Oct. | 9 | – | – | – | – | – | – | – | – | – | – | – | – | – | ·005 | ·005 | ·010 | ·085 | ·010 | ·005 | – | – | – | – | – |
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Hourly Rainfall at Kew Observatory, &c.—*continued.*

*Mr. G. J. Symons, F.R.S.*

13 Dec. 1882.

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | NOON. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | MIDT. |
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| 1878. | | | | | | | | | | | | | | | | | | | | | | | | | |
| Nov. | 8 | – | – | – | – | – | – | – | – | | ·095 | ·005 | | – | – | – | – | ·030 | – | | ·005 | ·045 | ·015 | | |
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| Dec. | 23 | – | – | – | Melted Snow at 10 a.m. = | | | | | ·200 | | – | | – | – | | – | | – | – | | – | | | |
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| 1877. | | | | | | | | | | | | | | | | | | | | | | | | | |
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| ,, | 26 | – | – | | Snow measured at 10 a.m. = | | | | | ·050 | – | ·020 | – | – | – | – | – | – | – | – | – | | – | | |
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Hourly Rainfall at Kew Observatory, &c.—*continued.*

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Hourly Rainfall at Kew Observatory, &c.—*continued.*

*Mr. G. J. Symons, F.R.S.*

13 Dec. 1882.

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6944. (*Mr. Lumley Smith.*) I do not know whether you are able to tell us the number of days in the year on which the rainfall in the whole of the 24 hours exceeded a quarter of an inch; have you checked that?—Not for this inquiry, but I remember looking into that point 15 years ago. The figures are printed, and I believe they are in my own volume of Rainfall for 1867. The value was, I think, 35 days of a quarter of an inch or upwards.*

6945. However, your tables which have been handed in show the hourly rainfall, so that it would be possible to calculate what the amount was in each 24 hours?—Yes.

6946. You have, in addition to that, prepared some tables, have you not, showing the amount of water that falls in the basin of the Thames?—Yes; of course I receive a very large number of returns regularly, but when I was informed that this inquiry was going on I was instructed to obtain accurate records of the rainfall over the whole of the Thames watershed. But I was further instructed that it was of more importance to obtain the information in greater detail respecting the lower tributaries of the Thames than respecting that portion which, combined, flows over Teddington weir. The consequence was, that I started what may be described as two separate investigations. I have handed round to the Commissioners some maps†, which I believe are before them, and on these maps will be seen the various water sheds. The principal ones are coloured, merely in order to make them a little more visible, the main river being left white all through. On these maps certain large numerals will be noticed; those numerals do not represent quantities of rain, or anything of that kind; they are merely reference numbers showing the position of the localities from whence I have obtained returns; and those returns I now propose to put in (*handing in some tables. See Appendices F. and G.*)

6947. Will you explain to the Commission what calculations those are, and what deductions you draw from them?—The fact is, that there are no calculations in them, for these tables simply represent in a convenient form the amount of rain measured at the respective places, of which the names are at the head of the columns, and of which the positions are shown by the numerals on the maps already handed in; that is to say, the top station marked Reigate, Woodhatch Lodge, No. 1 contains the observations made at Woodhatch Lodge, Reigate, in the month for which the sheet is, and the site of that gauge is shown upon the map by the figure 1, and the same remark applies to both tables. As to the deductions to be drawn from those tables, that is a question for engineers and not for myself.

6948. (*Chairman.*) Do these dots mean that there was no rain on those days?—Quite so. There is only one other point which I have to remark about, and that is this: that as a rough guide to the Commission as to the distribution of rain during the different months, I have had the values for two stations, for Oxford as representing the upper watershed of the Thames, and for my own station at Camden Square, as representing London, plotted on this diagram (*producing a diagram. See Appendix H.*) The heights of these various columns, as shown by the scale at the end, indicate the amount of rain. It is a scale exactly double the natural scale, and consequently shows at a glance the wet and dry periods during the months in question.

6949. (*Mr. Lumley Smith.*) Reverting to the earlier part of your evidence, a quarter of an inch is ·25 in.?—Certainly.

6950. Then dividing that by 24 it would not give actually the $\frac{1}{100}$th of an inch, but practically you have taken the $\frac{1}{100}$th of an inch per hour as being more convenient to work with than $\frac{1}{96}$th in.?—Yes, besides it is a question of rate, and not a question of total quantity. It is very rare that you get an equable rain throughout the 24 hours.

Cross-examined by Mr. Michael.

6951. What is the total annual rainfall in London?—About 24½ inches.

6952. Am I right in supposing you to tell the Commission that there are 90 days on which an average of a quarter of an inch falls?—I said that there was that number of days on which the fall in the hour was the quantity which I stated.

6953. It may be, therefore, that for one single quarter of an hour there was that quantity of rain falling, which, if it was spread over the 24 hours, would have amounted to ·25 in. or ·24 in.?—I did not say anything about quarter hours; I referred to hours. What I stated was this: that the total number of days with falls of $\frac{4}{100}$ths of an inch per hour, or upwards (it may have only lasted for one hour) was 90.

6954. Therefore, your giving us 90 days is no criterion of the quantity of rain which fell in those 90 days; it is merely as I understand you, that there did occur one single hour within the 24 hours in which the quantity which you take as your standard,

* British Rainfall 1867, page 28.

† *See* Evidence of Mr. Whitaker, Q. 6988, and *Appendix M.*

fell?—Quite so; that is to say, that during that one hour (or it may have been more) the rate exceeded $\frac{4}{100}$ths of an inch per hour.

6955. Have you taken out the number of days in the year in which ·24 in. or ·25 in. fell?—No; that question was asked me by the counsel, and I said that I did that many years ago, and I then found that it was about 35 days.

6956. Since that time has it been above or below the average?—The rainfall has been above the average the last few years.

6957. When you have taken that quarter of an inch, what do you wish us to understand as the result of your evidence; do you wish us to draw any conclusion that that quarter of an inch falling, or the division of $\frac{1}{96}$th of an inch falling, would come into the sewers at any appreciable time within the time of its falling as rain?—That is rather an engineering question than a meteorological one. I provide the actual meteorological facts; the interpretation of those facts is rather a question for engineers than for myself. At the same time, every one knows that if there is a violent rain, the rain rushes into the sewers, especially in these days of macadamized roads, asphalted pavements, &c.

6958. You are a scientific witness, and you are so thoroughly conversant with these matters that I need offer no apology for asking you these questions. You take the quarter of inch of rain as falling over a certain area; would you tell me how far that area extends?—I cannot tell, because this simply represents the fall at one place, that is to say, at Kew.

6959. It may have been so limited as to be an area of an acre, or a quarter of a mile, or a mile; you have no record of that at all?—No.

6960. But when we have to consider the question of the quantity of water not merely falling, but entering the sewers, ought we not to calculate the area over which that rain fell?—Yes; but speaking from my general knowledge of rainfall, I am quite sure that there is nothing exceptional in the frequency which is shown at Kew. It is true that very large rainfalls of two or three inches in an hour or couple of hours, are intensely local, but that does not apply to values such as are given here.

6961. May I ask, as a very careful student, month by month, and year by year, of your valuable records, whether it is not a fact, especially in London, that any heavy rainfall is, as you say, "intensely local"?—Generally.

6962. Is not an essential integer in calculating the quantity of water which would fall into the sewers, and so cause the storm overflows to act, and cause what my learned friend calls the sewage to enter into the Thames, the area over which that quantity of rain fell?—I am not an engineer, and I have not the remotest knowledge at the present time of how many storm overflows there are, whether there are two or whether there are 20.

6963. I am asking you a general and purely abstract scientific question, and I am sure you will answer me candidly.

(*Chairman.*) Recollect that the witness has told you that he is a meteorologist, and not an engineer.

(*Mr. Michael.*) I am not asking him an engineering question. I have a very profound respect for Mr. Symons, and I know that he is a very valuable witness, but he misapprehended the intention of my question. (*To the witness.*) I have nothing to do with the quantity of storm overflows; I merely put that in incidentally, so as not to take you at all unawares, and in order to explain to you the bent of my question; and I ask you again, whether before we can make your statistics of any value with respect to the quantity of water flowing into the sewers, we must not of necessity know the area over which the rain fell?—I should like you to define what you mean by "sewers," that is to say, whether I am to understand the sewers to apply to a piece of London, or to the main drains carrying the sewage down to Barking Creek.

6964. The whole of the system of sewers in London; but that has nothing to do with my question. Putting London out of the question, supposing that you are called, as you often are, as a scientific witness in these rooms to give evidence as to the capacity of pipes to carry off certain quantities of water, in order to determine whether a pipe will carry off the rainfall of a district, is it not essential to know over what area the rainfall has fallen, so as to be able to calculate the quantity which the pipes will carry off?—Certainly; but, as I have already stated, from my general knowledge as an observer, I am sure there is nothing in these sheets but what would occur in any part of London where you might happen to have put your gauge.

6965. At the same time?—Most probably at the same time. There may be a few instances here of heavy rains at Kew when there would not be heavy rain in London, and *vice versâ*.

6966. Would you kindly define what must be the quantity of rain before your own expression of "intensely local" applies?—I should say that a fall of upwards of an inch per hour is usually a local fall.

6967. How many such falls have occurred during the last five years, because they must be very rare?—That is hard to say. I have had two instances of $2\frac{3}{4}$ inches at my own place in five years. I do not suppose there is any other place in London that has had that luck, but I have happened to do so. I should think you might say that there have been perhaps eight or ten falls exceeding an inch in an hour. But I adhere to my original statement that certainly as regards this value of which we get the average of 90, I do not think that is disturbed to the extent of 10 per cent. by what can be called local falls.

6968. Supposing that there are 1,700 miles of sewers, and a velocity, I will say, of a mile per hour in the sewers, how long would your $\frac{1}{10}$th of an inch of rain take, if it had fallen over the whole of the area covered by these sewers of the metropolis, before it got to the outfall at Barking.

(*Chairman.*) That would require exceptional powers of calculation.

6969. (*Mr. Michael to the witness.*) Is it not obvious that if $\frac{1}{10}$th of an inch falls, say, at 6 o'clock in the morning of to-day, and is distributed over the whole of the system of sewers of the metropolis, it must take a very long period before the rain which has fallen at the extreme limit of the sewers will get to the other end?—I do not think so. Of course you are taking me off my own beat, as I said at the beginning, because I know nothing about the flow of sewage at all.

6970. Have you no observations at all on this pluviographical or hydrographical map which you have given us of the quantity of water that flows over Teddington Lock?—No, that is an engineering question. I have not the remotest idea of the quantity.

(*Mr. Lumley Smith.*) We shall be able to give that later.

6971. (*Mr. Michael to the witness.*) Nor can you tell us what influence an inch of rain, or $\frac{1}{10}$th of an inch, or $\frac{1}{96}$th of an inch, would have upon the river Thames?—Certainly not.

6972. Could you not give us any information with respect to the temperature during the period to which your observations refer?—I could get it probably as I could get any other scientific information which was required; but I have not investigated the point in any way whatever.

Examined by the COMMISSION.

6973. (*Colonel Ewart.*) Would you consider that, taking one day with another, the fall of rain registered at Kew Observatory would be a fair sample of the general fall over the metropolitan area?—I am quite sure that it would.

6974. (*Chairman.*) Then the result of your evi-

*Mr. G. J. Symons, F.R.S.*

13 Dec. 1882.

dence is that you think that for about 35 days in the year the rainfall would have exceeded a quarter of an inch in 24 hours?—I think it would have been ten times as great. Sir Joseph Bazalgette, I believe, puts it that a fall of a quarter of an inch per diem, or at the rate of the $\frac{1}{100}$th of an inch per hour (for it is only a question of rate) is a very extraordinary thing. In fact, it very seldom rains when it does not rain as much as the $\frac{1}{100}$th of an inch per hour.

6975. (*Mr. Abernethy.*) Sir Joseph Bazalgette stated that there were only from 14 to 21 days in the year on which the rainfall exceeded the rate of a quarter of an inch in 24 hours?—My answer to that is that it scarcely ever rains without exceeding that rate. If you go through these tables, which are detailed tables, there is no entry taken out which does not, during one hour of the day, exceed ·04 in., and the great bulk of these entries are much larger. I have underlined all the instances which exceeded $\frac{1}{10}$th of an inch per hour, ten times the quantity which he speaks of.

6976. (*Dr. De Chaumont.*) I do not think your last answer quite conveys what you intended to convey in saying that it seldom rains without raining as much as is stated by Sir Joseph Bazalgette?—It seldom rains at all without raining at a rate exceeding that which Sir Joseph Bazalgette looks upon as an exceptional limit. It is a question of rate as compared with the question of total quantity. Sir Joseph Bazalgette referred to a rate of a quarter of an inch per 24 hours; I say that you will find it scarcely ever rains at all unless it rains at a greater rate than that.

6977. Can you tell us what is the mean difference in any one day between the maximum and minimum over the metropolitan area?—It varies from nothing up to 400 times. I mentioned that there have been two instances of rainfall of $2\frac{3}{4}$ inches at my own house. On one of those occasions, towards Hampstead they had $4\frac{1}{4}$ inches in the 24 hours. On the other occasion the whole of the $2\frac{3}{4}$ inches fell in about an hour and three-quarters. It was about the heaviest rain I ever knew, and on that occasion the gauge at the New River Head registered something under half an inch, showing that the fall had fallen off from $2\frac{3}{4}$ inches to three-quarters of an inch or half an inch in three-quarters of a mile.

6978. That is an extreme case; but take a case where over the metropolitan area there was no greater rainfall than one inch at any one place; what would be the variation between that and the minimum?—I should say very probably from $\frac{8}{10}$ths in. to $1\frac{2}{10}$ths in.

6979. So that no station would give less than $\frac{8}{10}$ths of an inch?—I should think not. I should think the variation would not be more than 20 per cent.

6980. So that a rainfall of three-quarters of an inch to an inch would be pretty general over the metropolitan area?—It is usually so. I cannot go into all the details, but I recollect on one occasion I mapped a rainfall of about $1\frac{1}{10}$th in. which had fallen over the metropolis, and finding it was very equable over the metropolis, for curiosity's sake I prolonged it over the whole of the South of England, and I found a variation of only $\frac{1}{10}$th of an inch at all the stations up as far as the latitude of Bedford. The whole of the southern part of England had almost a precisely identical quantity; so much so, that I found who were good and who were bad observers by the irregularity in some of the amounts.

6981. (*Chairman.*) Would you draw any inference from the duration of the rain as to whether it was local or not?—Yes; as a rule these heavy rains are rains of very short duration.

6982. And therefore more local?—Quite so. It is the thunderstorm rains which are the local ones.

6983. (*Mr. Lumley Smith.*) I suppose if it was a short rain that only lasted for half an hour, or an hour, that would appear by your tables?—It would; because you have all the hourly details.

6984. (*Mr. Michael.*) But we have not the localities?—No, because there is only one; but, as I told you in the earlier part of my examination, I can have my own observations tabulated for the same period as are given here at Kew, and you can compare them with those at Kew. I do not think that there is anything else that is possible to be done besides that.

The witness withdrew.

Mr. William Whitaker, B.A., F.G.S., called in; examined by Mr. Balfour Browne.

*Mr. W. Whitaker, B.A., F.G.S.*

6985. You are a Fellow of the Geological Society of London, are you not?—I am.

6986. And you have been for 25 years on the Geological Survey of England?—Yes, for rather more than 25 years.

6987. In the course of your work in connection with the Geological Survey have you mapped the greater part of the Thames valley?—I mapped, I may say, by far the greater part of it myself.

6988. And I suppose this is the map that we have before us?—Yes. (*See Appendix M.*)

6989. In the course of making that map, I suppose you have acquired a very intimate knowledge of the geology of the whole of the Thames valley?—Yes; and not only of the part that I personally mapped myself, but I have had, as a rule, I may say, to see all, or nearly all, the other part mapped by various colleagues. I have practically seen all of it.

6990. I suppose in paying attention to the geology of the Thames Valley you have had to pay great attention to the question of water in the chalk?—Yes, it is a subsidiary subject to which I have given a good deal of attention.

6991. Have you made any special examination of parts of the valley of the Thames for the purpose of giving evidence before this Commission?—Yes; I have specially examined certain parts, as it was some time ago that my survey was made, in order to refresh my memory, and look at any special points that were involved.

6992. Can you tell the Commission whether or not wells in the valley of the Thames are commonly affected by the rise and fall of the tide?—Yes, it is a very common thing along the Thames valley, as along the margin of the sea and other water borders, that the wells should rise and fall with the tide to a greater or lesser extent, according to circumstances.

6993. Does the water in those wells become brackish in consequence of the infiltration of water from the river?—In some cases it does; not in all cases; but there are cases in which the water is not improved from that cause.

6994. For the purpose of this inquiry, I think you wish to make some remarks as to the geology of the valley of the Thames, first above London, and then below London?—Yes.

6995. First taking the valley of the Thames above London, are there any chances there of the infiltration of water through porous strata into the earth?—Above London, at least until you get to the neighbourhood of Windsor (which, of course, is beyond the limit of this inquiry), but certainly for a long way above the tidal part of the Thames, there is very little chance of such infiltration; indeed, the only chance of its occurring is through the permeable surface deposits off gravel and sand which overlie the London clay along the course of the river.

6996. Then, speaking generally, above London the river flows in impermeable strata?—Except the surface deposit. Underneath that there is an impermeable bed of clay of considerable thickness.

6997. (*Chairman.*) Can you give us any idea of the average thickness of that bed of clay?—It varies enormously, according to the position; but along the river it would reach probably to 400 feet at the most. When you get to Chertsey, I suppose there may be

about 400 feet of London clay. I cannot speak off-hand, it might be only 350 feet; but the gravel is thin; the gravel would rarely exceed 20 feet, but it is very irregular, it is generally less, very rarely more.

6998. (*Mr. Balfour Browne.*) The gravel which forms the bed of the river lies on the London clay, does it not?—Yes.

6999. Turning your attention to the river below London, is the same remark true of the bed of the river there?—No; below London a very different state of things sets in for the most part.

7000. What takes place there?—There is a slight rise of the beds, so that when you get below London the beds beneath the London clay rise up to, or nearly to, the surface; to the surface, I may say.

7001. Has the river so cut the London clay as to touch these beds below the London clay?—Yes, for some little distance below London; in fact, almost at the eastern edge of London the river begins to cut into these lower beds, and continues to do so for a great many miles, very nearly to the Nore; to below Thames Haven, in fact.

7002. And at Thames Haven I think the London clay comes down again and forms the bed of the river?—Yes, some little way below Thames Haven, before reaching Southend, that must be the case; the beds sink again.

7003. But between Thames Haven and the eastern edge of London, say Rotherhithe, are there permeable strata in the bed of the river?—Yes, and on the banks for the most part.

7004. Will you tell the Commission what those beds below the London clay are?—Those beds, we may say, are practically four in number. The first three are beds of Tertiary age; between the London clay and the chalk, beds more of the age of the London clay; a little older, but allied to it in age.

7005. Of what do they consist?—The first of those are what we may here call the Blackheath beds, beginning from the top in the order in which they rise from beneath the London clay.

7006. And that is the order in which you go down the river?—Yes. The Blackheath beds consist mainly of flint pebbles in a sandy matrix, and occasionally there are beds of sand as well.

7007. I suppose those beds of pebbles are permeable?—Perfectly, all through. They are sand and pebbles, and nothing else, in this particular district.

7008. What is the next in order?—The second in order to those is the set of beds known in this district as the Woolwich beds. They are a more varying set of beds. They consist of clays, of sands, and of pebbles.

7009. What about the permeability of those?—Of course the clayey part of them is not permeable, but the sands and the occasional pebble beds are permeable. They are very irregular in character; the clays are not always persistent, neither are the sands; they are an irregular set of beds, more clayey in one part and more sandy in another. In this particular district they are very largely sandy.

7010. (*Chairman.*) Where do they extend from?—The first set of beds (Blackheath Beds) occurs first in the neighbourhood of Greenwich. They are rather local; they extend to Erith, and then in patches eastward along the banks of the stream. The second set (Woolwich Beds) occurs between Deptford and Rotherhithe; they begin before the others, and they extend from there right down the river valley, except where they have been worn away and the chalk occurs.

7011. (*Mr. Balfour Browne.*) What is the third in your series?—The third is the mass of fine sands (except for a slightly clayey bed at the bottom; slightly clayey, I say, because it is more sandy than clayey), known as the Thanet sands.

7012. Are those permeable?—Yes, they are permeable throughout.

7013. And where do those beds occur?—Those beds occur first close to where the last-mentioned beds begin, a little above Deptford, and they extend afterwards right down the valley and far beyond it.

7014. What is the fourth set?—The fourth is the chalk, the lowest bed that we get in this part of the Thames valley.

*Mr. W. Whitaker, B.A., F.G.S.*

13 Dec. 1882.

7015. Where does that extend from and to?—It extends from Deptford right down the valley, being occasionally hidden, however, from just below Woolwich to near Erith, by some of the beds just described. In the neighbourhood of Woolwich, and from just above Erith to below East Tilbury, the bottom of the valley is wholly cut in chalk.

7016. Is the chalk a very permeable stratum?—Yes, as a rule it is, especially the part with which we have to deal here, that is to say, the upper chalk. We have nothing to do in this district with the lower, and sometimes less permeable, beds of the chalk; we have only the top 200 feet perhaps to do with, or not so much; 100 feet, I should think.

7017. You have described these permeable beds lying in the bed of the river; can you tell the Commission whether, at any part, the deposits of mud in the bed of the river would prevent infiltration of water into these permeable strata?—In some parts it is very probable that deposits of mud might have such an effect; but in a very large extent of its course, in the bottom part of the river itself, there is comparatively little mud, because we find that gravel, which is the same as that underlying the marshes, and occurring at the sides of the valley, is dredged up from the bottom of the river constantly; and more than that, there are places where anchors and such things touch the chalk itself, as near Gravesend.

7018. So that, where it does occur, its effect is simply local in protecting the permeable beds in the water?—Simply local.

7019. Is it your opinion that in the Thames below London there is plenty of opportunity for the infiltration of river water into the beds from which water may be drawn for supply?—Yes, the river valley there is so constructed, if I may use the word, or rather so cut out, that these mostly very permeable beds are open to the infiltration of water under proper conditions.

7020. If that water is charged with sewage, will the sewage also permeate into these permeable beds?—Naturally, a great part of any such water must be infected with any sewage that may be in it.

7021. Supposing that there are wells in the neighbourhood of the river, pumping water from those permeable beds, would that, in your opinion, facilitate the infiltration that you have been describing?—Certainly, if a large supply is pumped, it tends to lower the fresh water and to produce a cone of exhaustion which might result in a drawing in of the foul water.

7022. While the strata are thoroughly charged with water, that water would be, to some extent, a protection from the entrance of sewage?—Yes, while it is left in the natural state.

7023. But if that fresh water which is in the strata is pumped out, then it makes room for the sewage water to get into the strata?—Yes, it makes room for a certain amount of the bad water to get in.

7024. As a matter of fact, I think there were two large wells belonging to the Kent Waterworks at Charlton, were there not?—Yes, they had two pumping stations at Charlton on either side of the high road.

7025. Were those at any great distance from the river?—They are, roughly speaking, within a quarter or a third of a mile.

7026. And they are not very far from the southern outfall sewer of the Metropolitan Board of Works?—The southern outfall sewer goes very near them.

7027. Do you know as a matter of fact whether they have discontinued the taking of water from those wells?—Yes. I believe they have discontinued taking water from both of them now. They were used for some years. I cannot give the exact number of years, but they have been discontinued for some years now.

7028. Supposing the sewage to get into the river

*Mr. W. Whitaker, B.A., F.G.S.*

13 Dec. 1882.

and foul the water, would the effect of that sewage be found in the wells immediately, or would it take a long time, possibly, before it was found in the wells?—I should think that in many cases it would take a long time before the effect might be produced.

7029. Will you explain to the Commission why that is?—Because, of course, at first the amount of pollution would be comparatively small; it would not be until such sewage outfall had gone on for a long time that there would be so large an amount of foul matter in the river as to have an effect; and it would also take some time before the pumping would draw in such water.

7030. Therefore, of course, the more sewage there was in the river, and the more the pumping, the more you would expect the water to be affected by the sewage?—Certainly; as the throwing of the sewage into the river increases, and at the same time an increase of pumping takes place from new wells, or there is a larger drain on old ones, of course conditions are set up which are favourable to the drawing in of more water from the river.

Cross-examined by Mr. Bidder.

7031. The chalk basin under and around London is a great water-bearing stratum, is it not?—Yes, for the most part.

7032. It rises on both sides of London to hills of considerable altitude?—Yes, on the south nearly always, and on the north mostly.

7033. And the chalk under London, and under the River Thames, is charged with water which is under considerable pressure?—In most cases it is so, under natural conditions.

7034. And where it is bared to the river, the chalk would be a feeder of the river, and not the river of the chalk?—It would under natural conditions, or there might be a balance between them in some cases.

7035. So also, though possibly in a lesser degree, is it true of the upper beds, so far as they are water-yielding strata, that they are charged with water collected on the higher grounds?—Where they occur under the Thames, to a certain extent they would be, but the higher grounds are so much nearer that there would not be anything like the pressure there unless it were through the chalk.

7036. That is why I used the phrase "in a lesser "degree." Have you examined any wells?—Do you mean by gauging?

7037. I mean generally, in order to observe the fluctuations of wells with the tide?—No, I have not myself.

7038. Have you ever examined the phenomena yourself?—I have had records of them from many people, and information from the owners of wells.

7039. I suppose you know, as a geologist, that the fact of a well in the neighbourhood of a river, or of the sea, fluctuating in height in sympathy with the tide, by no means leads to the consequence that any of the water of the tide or of the river gets into the well?—Certainly; I have not said that it does.

7040. Have you any case to produce in which you have ever observed any well in the valley of the Thames which has exhibited any sign of being contaminated by sewage from the River Thames?—I have not actually observed the wells myself. I have not had an opportunity of doing so. I get records of hundreds of wells; I cannot see every well myself; I can only take the facts.

7041. Have you ever seen any instance yourself?—No, I have not. I have been at wells in which I have understood that there has been bad water, for instance, the trial boring at Crossness. I have been there while that was going on.

(*Chairman.*) We have the fact that he has not personally examined any of the wells.

Re-examined by Mr. Balfour Browne.

7042. I understand you to say that no doubt the chalk does at its outcrop get a considerable amount of rainfall into it?—Yes.

7043. In your examination-in-chief you spoke about a cone of exhaustion. When a well is sunk, does the well draw water from both sides of it, all round about it?—Generally speaking, it would, though it may be unequal on the various sides.

7044. So that if you sunk a well near the River Thames it would draw from the side on which the Thames was flowing as well as from the uplands where the water came from?—Certainly; it would have no more effect one way than another.

Examined by the Commission.

7045. (*Dr. De Chaumont.*) Have you any knowledge how far the tidal influence upon wells in the valley of the Thames is exercised?—No. I can hardly say off-hand. One hears occasionally of such an effect at a considerable distance, but I do not know that we have records at any very great distance. I fancy that is a question that will be answered by engineers better than by me. I cannot remember the records of the fluctuations of the water level.

7046. (*Dr. Stevenson.*) What distance were these disused wells from the outfall sewer?—I think they could not have been more than from a quarter to a third of a mile away. They were close by.

The witness withdrew.

(*Mr. Lumley Smith.*) I have one or two general witnesses whom I propose to call to-day, and I hope in January to bring what I may call the heavy engineering evidence before you.

Mr. Edgar Shand called in; examined by Mr. Lumley Smith.

*Mr. E. Shand.*

7047. I believe you are the manager of the London Steamboat Company?—Yes.

7048. Have you, all your life, been associated with the River Thames?—Yes, I was born on the banks of the Thames.

7049. Have you been conversant with the Thames all your life?—I have. I have resided in London all my life.

7050. Have you seen the sewage from the outfalls in the river?—Yes.

7051. Have you been able to trace it to see that it is sewage that comes from the outfalls?—Yes.

7052. Where have you seen it?—I have noticed it more particularly between Greenwich and Woolwich.

7053. Flowing in which direction?—I have seen it flowing both ways; I have noticed it flowing up the river as well as down.

7054. Your company is the company that carries all the passengers on the steamers up and down the river?—Yes, from Hampton Court to Ipswich.

7055. To what extent have you seen the sewage in the parts that you are speaking of, in isolated portions or in distinct tracks?—Distinctly in all parts of the

river, but more particularly between Greenwich and Woolwich, I have observed it. At Woolwich it was very bad.

7056. In the summer of 1881 did you see the river in a bad condition?—In 1881 it was the worst I have seen it. This present summer was not so very bad, but the year 1881 was very bad.

7057. What did you notice in 1881 which specially attracted your attention?—At those points, from Greenwich downwards, in fact, to the pumping station at Barking, I noticed the river very thick with a sort of glutinous matter, it seemed to be very thick indeed, and it was so bad that it used to cause bubbles. I noticed those bubbles, and I have seen them burst. It was in a very filthy condition.

7058. Was there any smell?—Yes, very bad indeed, the stench was something fearful, more particularly when the paddles of our boats moved from the pier.

7059. Have you had complaints about the river?—We have had continual complaints; in fact, I looked upon it as a very serious matter, on behalf of the company, at the time.

7060. From what class of persons did you get complaints?—From passengers, and from the captains and the men.

7061. Have you had any cases at all of actual illness caused to any of your crews?—No; not of actual illness, but we have had complaints of their feeling sick, and so on.

7062. Was that only in the hot months, that you have spoken of?—Yes, that was in the summer of 1881. I did not hear so much of it this year, although I have noticed it this year; but the river did not appear to be so bad.

7063. (*Chairman.*) You are speaking of very hot weather only?—Yes. In the winter time the water is very much better; but I fancy that that has a good deal to do with the land water that comes down.

7064. But, in point of fact, you have only observed that in very hot weather?—That is so.

Cross-examined by Mr. Bidder.

7065. How often does your duty take you between Woolwich and Greenwich?—In the summer time I am on the water every day.

7066. But between Greenwich and Woolwich?—Daily.

7067. When you say that you have seen the sewage between Greenwich and Woolwich, I want to get a little more definitely what you have observed; is it generally all over the river?—Generally all over the river.

7068. Of a glutinous consistency?—I have not noticed that glutinous nature this past summer as I did in the summer of 1881. In 1881 it was very thick indeed.

7069. Was it muddy to the sight?—No; there was evidence of soil from waterclosets, and all that sort of thing, floating about.

7070. You called it glutinous?—Yes.

7071. What you saw was general all over the whole river, and of course when the tide was going up it appeared to be going up, and when the tide was going down it appeared to be going down?—Yes, I observed it at all times of the tide.

7072. Did you trace it up above Greenwich?—No, I did not.

The witness withdrew.

Mr. Henry Jones called in; examined by Mr. Balfour Browne.



7073. Where do you live?—Woolwich.

7074. What are you?—A fisherman.

7075. And you have known the river a long time, I think?—Yes.

7076. I think you used to gain your living entirely by fishing at one time?—Yes.

7077. But now you have changed your occupation somewhat, have you not?—Yes; just now I have.

7078. What do you do now?—I get the fat off the river.

7079. Let me understand how you do this; have you a barge moored anywhere?—Yes, I have got a barge moored at Barking Creek.

7080. Is it in the creek itself?—Yes, inside the creek.

7081. How do you collect the fat?—I get it by a landing net, such as they have when they go fishing, when they catch the fish with a hook.

7082. Do you go out in a boat?—Yes.

7083. What do you do with the fat when you have collected it?—I take it on board and steam it in this barge that I have moored inside the creek.

7084. You go out in a boat, collect it into the boat, and then put it on board the barge and steam it?—Yes.

7085. I want to find out what parts of the river you get this fat in?—Sometimes at Blackwall, sometimes this side of Blackwall, and sometimes at Purfleet, according as the wind blows it.

7086. Do you ever go below Purfleet?—We could get it there, but there is not enough to pay us to go there.

7087. You stay at the fat part of the river?—Yes; there is a portion of it goes down below there a long way, but not enough to pay us.

7088. After you have steamed the fat, do you sell it?—Yes.

7089. I hope you make a good living out of it. I do not suppose you know what becomes of it afterwards, do you?—No.

Cross-examined by Mr. Bidder.

7090. Do you eat Dutch butter yourself?—No.

7091. Your barge is moored in Barking Creek?—Yes.

7092. And that is your headquarters?—Yes.

7093. At what time of the tide do you go?—Mostly upon the half flood, according as the wind is. It is the wind that has a good deal to do with our stuff; and we have to follow it about according as the wind blows.

7094. In the neighbourhood of the outfalls?—We have to go miles below, sometimes we have to go to Purfleet.

7095. You go to the eddies where the wind has blown the scum into a bay of the river, and there you collect it?—Yes, that is exactly it, and we get our living by watching the wind; where the wind blows it, we know where to find it.

7096. And that is what takes you sometimes up and sometimes down, according as a strong wind may blow it one way or the other?—Yes; sometimes it is all of a heap, and that suits us better.

7097. When the wind is not blowing, do you ever go actually to the outfall itself?—Yes, when there is no wind.

7098. Do you go close to the outfall?—Yes, we go there every tide.

7099. Do you enjoy pretty good health?—Yes.

7100. Do you ever work in Barking Creek?—Yes.

7101. You get a pretty good take there sometimes, do you not?—Very often we get a nice lot there; not far up the creek, about a quarter of a mile.

*Mr. H. Jones.*

13 Dec. 1882.

Re-examined by Mr. BALFOUR BROWNE.

7102. What part of Barking Creek do you get it in?—About a quarter of a mile from the mouth we get it.

7103. Can you tell where the fat comes from that you get in Barking Creek?—From the outfall. I am perfectly satisfied of that.

7104. How does it get in there?—The south-west wind blows it in; and the creek has a great draught to it, and it draws everything in it.

7105. Do you live on board the barge, or where?—I live at Woolwich.

7106. Has this fat that you get off the surface a disagreeable smell?—No, not at all.

The witness withdrew.

Captain HENRY WEBB called in; examined by Mr. LUMLEY SMITH.

*Capt. H. Webb.*

7107. I believe you are the captain of the "Cupid," which runs between Woolwich and London Bridge?—I am at present.

7108. And you have been employed on steamers plying up and down the river for 38 years?—Yes, for nearly 40 years.

7109. I believe you have a Trinity House Pilot certificate?—I have.

7110. And you know the river thoroughly, I believe?—I do.

7111. You remember the opening of the outfall, do you not?—Yes.

7112. At that time was the water between Westminster and Woolwich better or worse than it is now?—Worse.

7113. Since the outfalls have been opened, have you found any change in the water?—Yes, we get the stench further down now.

7114. And it is better up in the London district?—Very much better.

7115. And worse lower down?—Yes.

7116. What do you find to complain of in the water lower down now?—There is a very great stench when we get under weigh with our boats running down, when we are running two boats together. If we get to leeward at all, the boat to windward of us stirs the stuff up from the bed of the river, and it causes a great stench to the boat that is to leeward

7117. In what parts of the river do you find that?—From Barking to the lower part of Halfway Reach is the worst of it; but we have had it very bad from Blackwall to the "Rising Sun" point in the lower part of Long Reach.

7118. Have you seen the sewage above the outfalls?—I cannot say whether it is sewage, or what it is; I know the water is very black, and smells very bad.

7119. At what time of the year have you seen it?—In the summer season. I do not run down there in the winter.

7120. Have you had complaints from passengers?—Yes, frequently.

7121. What do they complain of?—Of the stench of the water. If a boat happens to be passing us at the time, there is hardly a passenger aboard but what is obliged to put his handkerchief up to his face to avoid the stench.

7122. That, I suppose, is in hot weather?—Yes; more especially in the year before last.

7123. Are you acquainted with the tides in the river?—Yes.

7124. First of all, with regard to the flood and the ebb, which is the stronger of the two?—The flood.

(*Mr. Bidder.*) You have exact experiments of Captain Burstal's, and surely it is not worth while going into this.

(*Mr. Lumley Smith.*) I have other evidence of exact experiments that have been made for the purpose of this inquiry.

(*Chairman.*) That will be more material.

Cross-examined by Mr. MICHAEL.

7125. Do you enjoy pretty good health?—Yes, very good. I am not often troubled with a doctor.

The witness withdrew.

Captain THOMAS HUNTINGFORD called in; examined by Mr. BALFOUR BROWNE.

*Capt. T. Huntingford.*

7126. I think you are the captain of the "Duke of Edinburgh," which is a steamboat in the service of the London Steamboat Company?—Yes.

7127. And you hold a pilot's and master's certificate from the Trinity House, do you not?—Yes.

7128. How long have you known the river?—All my lifetime; I was apprenticed to it.

7129. Can you tell the Commission how far from the outfalls the sewage is visible in the river?—I should think a couple of hundred yards.

7130. That is from the outfall into the body of the river?—Yes.

7131. Is the colour of the water at any other part of the river different from that?—No, not a wonderful deal; it is generally there where we catch the two different colours of the water.

7132. Is the water at any time in Crossness Reach, or Halfway Reach, as it is called, very clear?—It is never clear—pretty well half-water off.

7133. Is it always coloured?—Always.

7134. How do you account for that?—Through its being in an eddy, where it cannot get away.

7135. Is there not sufficient run of the tide through Halfway Reach to carry it through one way or the other?—No; only the first quarter's ebb tide that sets into Crossness; after that the eddy begins to form on account of the tide setting strongly from the Halfway House point down towards the Dagenham shore. A north-west wind would clear it away lower down the river.

7136. How does the flood set into the Crossness bight?—The first quarter's flood tide will set into Crossness; after that the eddy begins to form on account of the tide setting strongly from Jenningtree Point over to the Dagenham shore, leaving Crossness nearly three parts of the tide in an eddy.

7137. Is that after the young flood?—About the first hour-and-a-half flood.

7138. Is Bull's Point on the Dagenham shore?—Yes, only much higher up; Bull's Point is abreast of the Arsenal.

7139. What is the condition of the river, so far as the set of the tide is concerned, from Bull's Point to Woolwich Pier?—It is in a very bad condition. I notice the stench of the water more there than in any other part of the river. That is where I first fell in with it.

7140. (*Mr. Bidder.*) Where is Bull's Point?—Abreast of the Arsenal, on the north shore.

7141. (*Mr. Balfour Browne.*) At that place where you say you noticed it most, between Bull's Point and Woolwich Pier, is there an eddy?—Yes. I am speaking of North Woolwich Pier. The first quarter flood sets in there.

7142. And is that the cause of the stench of which you complain?—Quite so. After the first quarter-flood there is a down current that brings it back along the North Woolwich Gardens to Bull's Point, and there it will hold itself.

7143. Your evidence is that, owing to these sets of the tide, it does not get away?—It cannot.

Cross-examined by Mr. Bidder.

*Capt. T. Huntingford.*

13 Dec. 1882.

7144. Do you know that big drain at North Woolwich by the pier?—There is a drain pipe by the Telegraph Works.

7145. Near the Ferry Pier?—It is above the Ferry Pier.

7146. Have you noticed the stuff coming out of that?—No; only when they have a great deal of rain they are bound to ease it off the land.

7147. You are not aware that that drains a large number of houses?—No. I have been by it a good many times in a row-boat, but I never got any smell from it. I never saw anything come out unless there were heavy rains off the land.

7148. (*Chairman.*) What is the size of that drain at North Woolwich?—It is an iron pipe about four or five feet in diameter,* by Henley's Telegraph Works.

7149. (*Mr. Abernethy.*) Have you ever measured it?—I have not.

7150. (*Chairman.*) You could almost get into it?—Yes, I could get into it nicely. It lifts up with a large trap; but I never saw anything come out of it.

(*Mr. Bidder.*) I am not sure that you know the right one. We will get evidence as to this from somebody else.

Re-examined by Mr. Balfour Browne.

7151. At any rate you never got any smell from that?—No, never.

7152. (*Mr. Bidder.*) North Woolwich Pier is where you always find a smell?—Yes, in going down; if we gave a stir with the engine, that would throw up the scent from the water.

7153. Close by the Woolwich Pier?—Yes, alongside the pier.

Examined by the Commission.

7154. (*Chairman.*) Is there a pipe coming out into the river?—It comes out into the shore down to low-water mark.

7155. And you have seen stuff coming out of it?—I do not know that I have ever seen much come out of it. There may be a little water running out of it, but that is all.

7156. (*Dr. de Chaumont.*) You said that you traced the sewage from the outfall for 200 yards; do you mean across the river or up and down the river?—I mean across the river, with a strong south-west wind.

7157. How far up or down have you traced it?—I have traced it nearly a quarter of a mile up the river, up to Halfway House Point, above the sewers.

7158. (*Chairman.*) Then, when you said 200 yards, you meant across the river?—Across.

7159. (*Dr. de Chaumont.*) Have you traced it down the river also?—We can trace it down to Jenningtree Point; after that it all gets coloured alike very thick as low down as Greenhithe.

7160. (*Chairman.*) You never noticed it below Jenningtree Point?—Never to hurt. There is no smell.

7161. You notice it down to Jenningtree Point and up to Halfway House Point?—Yes, Halfway Reach is two miles in length. Halfway House Point is about a quarter of a mile above Crossness.

7162. Then you never notice it up as far as North Woolwich?—No; the water all seems to get discoloured alike when you get up there; but in Halfway Reach you see two colours like that table, one black and the other a lighter colour.

7163. The two things are in separate streams from Jenningtree Point up to Halfway House Point?—Yes.

7164. And then you say they meet, and you cannot distinguish them?—You cannot up at North Woolwich Pier, because they get into a truer run of the tide. This is in the eddy.

7165. When they do meet, have you noticed the state of the water from that point?—It is very thick.

7166. Up to where?—The river is all over alike now, pretty well.

7167. Up to where?—I would say as far as Greenwich, if the tide is running strong. It is according to the run of the tides. In spring tides it will be thicker than in neap tides.

The witness withdrew.

Mr. Edwin Martin called in; examined by Mr. Lumley Smith.

*Mr. E. Martin.*

7168. Are you the pier master at South Woolwich?—Yes.

7169. How many years have you been there?—Eighteen.

7170. Do you remember the opening of the outfalls at Barking and Crossness?—Yes.

7171. That would be, I suppose, about the time of your going there?—After that some considerable time. They have not been opened 18 years yet.

7172. When you first went to Woolwich were you pier master?—No, pierman.

7173. What was the water like then in the neighbourhood of the pier?—Very different from what it is now.

7174. Is it better or worse now?—Much better.

7175. Was it clearer or not?—It was much clearer. You could catch anything there then, flounders and shrimps.

7176. What is it like now?—It is different at times. When they let the stuff out of the sewers on the flood it is very black.

7177. Do you find that a blackness comes into the water then?—Yes; and there are little round balls of fat that drive by. That is the way we find out when they are letting it out on the flood.

7178. You find balls of fat come driving by the pier?—Yes.

7179. Do I correctly understand you to say that the water is blacker then?—Yes, much blacker.

7180. Do you find the balls of fat come by on the flood frequently?—After heavy rains or snow, or anything like that, when the sewers are heavily charged, they let this stuff out.

7181. Have you noticed at all the wind, so as to see whether these balls of fat are brought up by the tide or blown up by the wind against the tide?—If we have the wind on our shore, they will come on our side, and if it blows off our shore, they will go on the other side.

7182. Do they come up with the flood?—Not as a general rule, but sometimes after heavy rain or after low water you will see them as soon as the flood makes.

7183. Are you much troubled with mud at the pier?—At times, and sometimes it shifts.

7184. Is that stirred up by the tugs?—We have sometimes two or three of them at a time, and then they stir it up, and it is a sort of blue-black colour, and the stench is something horrible then; it is simply awful.

7185. Are you familiar with ordinary Thames mud?—Yes.

7186. Is it at all like that?—No, it is not at all like that; it is of a blueish black.

7187. Have you ever experienced any ill effects from it?—I could not say that I have. Twice this year I have been away for three days, but I could not say that that was the effect of this.

* Subsequently altered by witness to *two* feet in diameter.

Cross-examined by Mr. BIDDER.

*Mr. E. Martin.*
13 Dec. 1882.

7188. When did you last see the balls of fat off Woolwich Pier?—I saw them a hundred times this summer. I could not give any date. I was never "taxed" with any date.

7189. When was the last time that you saw them?—I could not say the date. I might say I saw them three or four times last month.

7190. How long have you been stationed there?—Eighteen years.

7191. Where were you before that?—Under Government; in the Ordnance.

7192. At Woolwich?—No, at sea.

7193. Then you must have gone to Woolwich about the year 1864?—I was born in Woolwich.

7194. I did not ask you where you were born, but you must have gone to Woolwich in 1864?—Yes, if that is 18 years ago. It will be 18 years, come the 28th of next month.

7195. It was in January 1865 when you first went to Woolwich?—Yes, on the 28th of January.

7196. Previously to which you had been at sea in one of Her Majesty's ships?—Yes.

The witness withdrew.

Adjourned to Tuesday, the 9th of January, at half-past twelve o'clock.

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# FOURTEENTH DAY.

## Tuesday, 9th January 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR P. BENSON MAXWELL.
SIR JOHN COODE, MEM. INST. C.E.
COLONEL C. B. EWART, C.B., R.E.
FRANCOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary.*

9 Jan. 1883.

*Mr. Lumley Smith*, on behalf of the Corporation of the City of London, expressing his great regret that the scientific witnesses whom he had hoped to be able to call to-day, had found it impossible fully to complete their extensive observations, and the necessary deductions from them, prayed the indulgence of the Commission, and begged a fortnight's adjournment. At the same time he handed in sundry diagrams, with explanatory memoranda, of float experiments in the Thames.

*Mr. Bidder* urged that at all events the chemical evidence might be proceeded with, submitting that that must be to a large extent matter of fact, and independent of the engineering observations.

*Mr. Lumley Smith* stated that the labours of the chemists were so largely conjoint with those of the engineers and other scientific observers, that he was unable to proceed with the chemical evidence separately at the present moment.

*Mr. Bidder* was heard to protest against any delay which could possibly be avoided.

After a short discussion

*The Chairman* intimated that the Commission had decided that the next meeting should be fixed for this day fortnight, the 23rd instant, by which time the representatives of the Corporation should at any cost or trouble to themselves be ready to proceed; but that if by any chance they felt at the end of a week from to-day that it was impossible for them to be prepared by the 23rd, they must give notice and apply for a short extension of time; otherwise, failing such notice, the Commission would proceed peremptorily on the 23rd instant.

Adjourned to Tuesday the 23rd of January at half-past 12 o'clock.

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# FIFTEENTH DAY.

## Tuesday, 23rd January 1883.

PRESENT:

THE RIGHT HONOURABLE LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR P. BENSON MAXWELL.
SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOS. STEVENSON, ESQ., M.D.
WILLIAM POLE, ESQ., F.R.S., *Secretary.*

23 Jan. 1883.

*The Chairman*, in reference to a paragraph which had appeared in the newspapers purporting to describe the proceedings at the last meeting of the Commission, intimated that it must be clearly understood that all who were admitted before the Commission were present on sufferance only, and must conform to the rules laid down by the Commissioners, which prohibited any report or reputed report of their proceedings to the public press.

In anticipation of evidence, a "Report on the Observations made in the River Thames," by Mr. Baldwin Latham, M. Inst. C.E., was handed in. (*See Appendix R.*)

Mr. Baldwin Latham, M. Inst. C.E., F.G.S., F.M.S., examined.



7197. (*Mr. Webster.*) You are a civil engineer, practising at Westminster?—I am.

7198. Have you devoted your attention for a great many years to works connected with sewage and drainage, and to tidal outfalls?—I have.

7199. Were you, some months ago, requested by the City solicitor to investigate the discharge of the sewage into the Thames?—I was.

7200. About how long ago was that?—I think it was last June.

7201. I think Mr. Mansergh, Mr. More, and Mr. Birch have, from time to time, assisted you?—Mr. Mansergh and Mr. More were associated with me as engineers, and Mr. Birch was engaged in looking after the float experiments.

7202. Will you just tell us what steps you took, in the first instance, to ascertain the horizontal range of oscillation of the tides near the point of the northern outfall?—A series of floats of the description of the one which has been exhibited to-day were put into the Thames.

7203. And their motion was watched?—And their motion was watched night and day. There were two men engaged in a small boat by day and two men in a boat by night watching each float, and the men were generally superintended by Mr. Birch and his staff from the steam-tug "Toby."

7204. What are the dimensions of the floats?—The floats are 12 feet 6 inches in length and 11½ inches in diameter.

7205. And what cross section are they; are they circular?—They are octagonal, the object being to offer, as nearly as possible, the same surface to the water in every direction if they revolved. They were immersed about 12 feet on the average, sometimes more and sometimes less.

7206. That is to say, they would stand upright in the water?—They would stand upright in the water; if they were down in the lower part of the river they would be a little higher out of the water.

7207. (*Chairman.*) On account of the proportion of salt water?—Yes.

7208. (*Mr. Webster.*) The floats stood vertically in the river you say, and I want to know, taking the average, how much would be out of the water?—There would be from 6 inches to a foot on the average out of the water; as a rule, they would be immersed 12 feet.

7209. Would the maximum be 6 inches out of the water?—The minimum would be 6 inches.

7210. And the maximum what?—Perhaps a little less than a foot; it is very difficult to say precisely, because the movement of the surface of the water prevents your ascertaining exactly.

7211. With regard to the rise and fall of the tide, I suppose you took observations by tide gauges?—We have made use of such existing recording gauges as were upon the Thames, and we have put up a number of others, especially upon that part of the river (the lower part) where there were no gauges, and where it was more important to carry on the observations than in the higher part of the river.

7212. What do you take to be, for the purpose of your evidence, the total drainage area of the River Thames?—The total drainage area of the River Thames has been ascertained by the report of the Rivers Pollution Commission on the Thames, March 1866, to be 5,162 square miles.

7213. Have the Thames and its tributaries been gauged in any places?—Yes.

7214. In how many different places?—The Thames, and the whole of the tributaries which could be gauged, have been gauged, because it was of very great importance to ascertain what was the volume of water coming into the river at all points.

7215. (*Chairman.*) Taking the 5,162 square miles which you mentioned, to what point would they include?—Down to Southend—really to the mouth of the Thames itself.

7216. (*Mr. Webster.*) That is to say, going from Southend up to and including the water that comes in at Teddington?—Mr. Symons on the last occasion put in a plan which showed the drainage area of the Thames.

7217. (*Chairman.*) That means, I suppose, including its very source?—Yes, including its very source.

7218. And down to the mouth?—Yes.

7219. Inasmuch as we know that from its source to Sheerness the distance must be about 120 miles?—The river itself is 201 miles in length.

7220. But an air line from its source to Sheerness would be how much?—That I have not measured, but 201 miles is the length of the channel.

7221. The average breadth of the drainage area could not be above 50 miles?

7222. (*Sir John Coode.*) Speaking broadly, it is 50 miles?—No doubt.

7223. (*Mr. Webster.*) Of that 5,162 square miles, I think, 500 are due to the drainage area of the River Lea?—About 500 are due to the drainage area of the River Lea.

7224. You have given the drainage area to a point much below the outfall, I think you mentioned Southend?—Yes.

7225. For the purpose of your subsequent deductions, is the quantity of water in the river below the outfall a matter of importance?—Yes, of very great importance.

7226. Has the water flowing from that 5,162 square miles been gauged, with the exception of 284 square miles?—Yes. In the Report which has been put in you will see the number of the tributaries which have been gauged, but in some of these cases they were gauged at more than one point; there are 50 points at which we have carried on gauging operations.

7227. Will you tell me what steps have been taken to ascertain the quantity of water flowing from the 284 square miles which you could not gauge?—The quantity of water flowing from that 284 square miles has been arrived at by taking a similar area which has been gauged, below Teddington Lock, and calculating the number of cubic feet every day which has been found to flow from the ungauged area, to represent the exact area, and the result is given in the Table of Gaugings. That 284 square miles has been divided into two portions, one above the northern outfall and the other below it. I might say that the 284 square miles that were not gauged represent one-eighteenth part of the whole drainage area.

7228. Have you also taken the quantity which is taken for water supply purposes and afterwards returned to the Thames, after having been used?—Yes, we have taken the quantity from Colonel Bolton's monthly tables, and averaged it out to the daily quantity in the same way as the other gaugings have been taken.

(*Chairman.*) All this is in Mr. Latham's Report, is it not?

(*Mr. Webster.*) It is as far as I have gone.

(*Chairman.*) Because we have already looked carefully over this report.

(*Mr. Webster.*) That report, I hope, will be taken as having been put in—we could not, of course, take it as being read.

(*Chairman.*) Mr. Latham will, no doubt, say that report is accurate, unless he is inclined to correct or qualify it in any way, therefore that is his evidence to a certain extent.

(*Mr. Bidder.*) As far as we are concerned, that seems a desirable way of dealing with it, subject to one thing, and that is, that my learned friend at the proper time will call the witnesses who took these float observations. I have a very good reason for asking that that may be done.

(*Chairman.*) You do not agree that the observations themselves are accurate?

(*Mr. Bidder.*) I have the best reasons for believing

*Mr. B. Latham, M. Inst. C.E., F.G.S., F.M.S.*

23 Jan. 1883.

that there are serious mistakes in the observations themselves.

(*Chairman.*) But still you may take it that Mr. Latham in his evidence in chief says, "This is my report, and you may take it as right."

(*Mr. Bidder.*) Of course he will not say that the observations themselves are correct, but that the calculations are correct as far as he is concerned.

(*Mr. Webster.*) It is essential that this report should be upon the proceedings.

(*Chairman.*) Certainly. It must appear upon our proceedings; there is no doubt about that.

(*Mr. Bidder.*) All I desire that my learned friend and your Lordship and the Commissioners should clearly understand in the present state of the proceedings is, that I shall challenge the correctness of many of the observations themselves.

7229. (*Chairman to the witness.*) Many of the statistics in this report are not, I presume, the result of your own actual inspection?—Of my own inspection they are; nothing has been done which has not been under my inspection and supervision.

7230. But you could not undertake to say that there is nothing here which is not within your own knowledge?—No.

7231. (*Mr. Webster.*) A number of the observations upon the floats were supplied to you by the people who actually watched the floats?—Yes.

7232. You have not constantly watched the floats yourself?—No, I did not of course watch the floats night and day.

7233. (*Chairman.*) You could not say, for example, that upon the morning tide of the 15th of October the float was 19·30 miles above the outfall?—No, I could not say that.

7234. (*Mr. Webster.*) Upon many occasions you saw the observation taken?—Yes.

7235. (*Sir John Coode.*) They were taken under your direction and supervision?—They were.

7236. (*Mr. Webster.*) But you relied upon other persons for the detailed figures which appeared upon your report and your diagrams?—Yes.

(*Mr. Webster.*) With regard to what my learned friend, Mr. Bidder, has said, subject to the approval of the Commission, the City will be prepared to call any witnesses he may ask for.

(*Chairman.*) Yes, if the Board tell you that they want any of those witnesses called, you must call them.

(*Mr. Bidder.*) What I mean is this, that I have a very grave reason for thinking that many of these observations (I do not suppose they were taken when Mr. Baldwin Latham was present) are inaccurate, and that very likely in the night the float has not been continuously at work. You will understand that it makes considerable difference in the progress of a float whether it has been anchored half the night or not, and therefore having good reason to believe that that has been the case in many cases;—

(*Mr. Webster.*) I intimated that I was ready to call anybody my learned friend required, subject to the discretion of the Commission.

(*Mr. Bidder.*) It is hardly for me to indicate the witnesses who should be called.

(*Mr. Webster.*) But you can say with regard to which float you would like to have those who made the observations examined.

(*Witness.*) I would like to call the attention of the Commission to the fact, that upon the afternoon tides the range is greater than it is upon the morning tides, showing that the float could not have been anchored.

(*Mr. Bidder.*) My learned friend is not going to rely upon my giving notice of a particular person to be called.

(*Mr. Webster.*) Certainly not, I am not going to be so unreasonable. I will give any class of evidence you require.

(*Chairman.*) Mr. Bidder may say, if he thinks fit, call A.B., or call the man who was doing this, that, or the other, or he may say, call all your men who furnished the materials from which Mr. Latham made his observations, and you will do it.

(*Mr. Webster.*) Certainly; we should not be here to produce this evidence before your Lordship if we could not do that.

(*Mr. Bidder.*) I ought to go a step further in fairness to my learned friend, and tell him that I shall at the proper time adduce in evidence simultaneous observations which are quite inconsistent with these, and therefore of course both cannot be right. I have told my learned friend that in advance, as I did not wish him to be taken by surprise.

7237. (*Mr. Webster to the witness.*) There are one or two data which I must get for the purpose of founding the equation upon. The position of the outfalls we know, will you tell us one or two distances which are necessary for your subsequent evidence. From the northern outfall to Crossness is about a mile and a half, is it not?—From the northern outfall to Crossness the distance is about a mile and a half.

7238. From the northern outfall to Erith pier is five miles?—That is correct.

7239. From the northern outfall to the Town pier, Gravesend, the distance is $14\frac{3}{4}$ miles?—Yes.

7240. And from the northern outfall to Cliffe Creek the distance is $18\frac{3}{4}$ miles?—Yes.

7241. Has a cross section of the river been taken at any point?—Yes, Mr. Mansergh and Mr. More have very carefully surveyed the whole of the river with the view to arrive at the capacity of the river from the area of the cross sections.

7242. And have you used those sections?—I have used them for the purpose of certain calculations.

7243. Will you tell me shortly what are the two actions which take place in order to get the sewage out to sea, from, we will say, the northern outfall, what happens to it, after it is turned out into the water?—After the sewage is turned out from the outfall it would flow down with the tide to a certain point and be brought back again by the next tide to a certain other point, up the river; and that process would go on, backwards and forwards, taking a longer time than one lunation, until fresh upland water coming into the river displaces the matter and gradually drives it out of the river.

7244. As far as the tide is concerned the sewage poured in at one outfall, taking the northern outfall for instance, would oscillate backwards and forwards?—Yes.

7245. That would be the action of the upland water, little in dry times, and heavy in flood times, to drive it further down the river?—Yes.

7246. What other process goes on which has a tendency to take the sewage out of the water?—The mixing, which has a very powerful influence, much more so than the actual displacement.

7247. Will you tell the Commission what you mean by the mixing action?—Mixing with sea water takes place when the water flows down the river; if you put a float, we will say, in the water, and let it float down the river, you will find by taking samples of the water, all along its course down the river, that the water becomes more and more salt as it passes down the river.

7248. Assuming a volume of sewage to be poured out on the top of high water, and that it would come into tidal water, partly salt and partly fresh, there being no sewage there before, as it goes down it comes into a wider area; the area of the cross section of the river increases in size?—Yes.

7249. Therefore, there would be a larger volume of water into which it would go?—Yes.

7250. Then when it is returned it is more diluted than if it had been in a parallel channel all the time of a small size?—Yes.

7251. This goes on contemporaneously, and is what you call the mixing action?—Yes.

7252. Is there also a mixing action due to the flowing in of fresh water at the top?—Yes, it takes place both ways. If there were no mixing action, all the water from the range of one tide to the mouth of

the river would be fresh water, but as it is, we found upon the 14th September, at high water, an amount of sea salt in the water at Chiswick, showing that it could only have been brought up to that point by the mixing action.

7253. I do not want to anticipate the detail. I will get that afterwards. You have examined as carefully as you could, to find out the effect of the oscillation or floating backwards and forwards of the dirty water, and also of its being mixed with other water?—Yes, I have.

7254. Have you put down the result of what you believe to be true observations in the shape of a diagram?—These diagrams before the Commission, show the various floats up to No. 7. (*See Appendices S. and T.*)

7255. Turning to the first page of the diagram, will you just show the Commission what was the operation of No. 1 float. I think you began upon the 14th of September and had to commence again?—The experiments were intended to begin at spring tides upon the 14th of September, but, owing to the men being new to the work and a fog coming on that night, the experiment broke down, and it was not until the 17th of September that the experiments were fairly started.

7256. You started upon the 17th of September at high water, at what place?—The float was put in the centre of the river at high water, opposite the northern outfall.

7257. How far did it float down?—It was put in at 25 minutes past 4 p.m. on the ebb tide; it descended as far as Denton Wharf, 15·84 miles below the point at which it was put in.

7258. Was the tide neap or spring?—The tides were then taking off; the tide had been high spring upon the 14th.

7259. How much was it after the high spring?—Three days.

7260. The course of that float is shown according to its tidal range, for the period of seven days, until it has reached a point opposite Higham Bridge, just below Holt; is that correct?—Yes.

7261. It appears to have gone higher up than the outfall between the 28th and the 29th of September?—Yes.

7262. I think the highest point it reached was just to touch Woolwich Station, was it not?—Upon the 29th.

7263. For how long was the float watched?—Upon the 29th of September the float had reached a point in Woolwich Reach, 2·08 miles above the northern outfall.

7264. Is there any special cause upon that day with regard to that float going up as high as that?—It will be seen that it was a spring tide, so that the range is greater and the wind was slightly up the river.

7265. Is the effect of the spring tide that the water flows up the river at a greater rate of rapidity than a neap tide?—Yes.

7266. It is not merely that a greater volume of water comes in, but it flows up at a greater rate of rapidity?—It must naturally do so if a greater quantity comes in.

7267. It has a larger quantity to get up in the same time, and therefore it must come up more rapidly, and therefore you will expect upon a spring tide to find a greater operation upon the float?—Yes.

7268. I think we will just go through them; upon the 13th of October that float was lost?—Whenever there is any hitch in the management of the float, it is shown by a black dot upon the diagram.

7269. I notice that upon the 17th of October the float got up still higher again?—Upon the 17th of October.

7270. Mr. Bidder suggests that it was lost altogether, will you show where it was found again?—You will see in the report what exactly happened upon that day. "Upon the 13th October, at high water, on the "morning tide, the float was in Halfway Reach, "1·76 miles below the northern outfall sewer, and "about two hours after the return of the float down "the river, a fog came on and the float was lost. At "noon the same day, it was again started in a position "with reference to No. 4 float, which had been con-"tinuously working during the period."

7271. That is to say, you put the float in when it was found again at noon the same day, the same distance from No. 4 float as it had been when it was lost?—That is so.

7272. How long did this float go on?—It went on continuously till the end of the observations, until the 24th of October.

7273. Then it was stopped by the gale?—The weather became very unsettled about that period.

7274. Will you tell me what general deduction you draw from that float?—It is given at page 12 of the report, that in the 45 days this float was in the river it only progressed 2·20 miles down the river; but if we take two complete lunations, ending upon the 16th of October, the float had descended two miles. In the 26 days, in which there was no break whatever in the experiments, that is, between the 17th of September and the 13th of October, the float had only progressed down the river 1·76 miles below the northern outfall.

7275. What do you mean by progressing down?—From the point where it was put in down to the point where it was found.

7276. From the point where it was at the beginning to the point where it was at the end?—Yes. At the same state of the tide.

7277. I believe No. 2 float, though it was lost, was found again, and there does not seem to have been much wrong with it during the fog; that was in continuously from the 17th of September to the 19th of October?—That is so. I may mention that with regard to that, as a condition of doubt occurred, it is shown by a dotted line on the diagram instead of by a full line.

7278. It is clear, by the dotted lines, that nothing happened to it, because it appears to have gone on in the same way as before?—Yes, that is so.

7279. (*Chairman.*) Of course this float would ground every now and then, unless your men in the boat prevented it, would it not?—All these float observations were done under written instructions from myself, and one of these instructions was that the men were not to interfere with the float unless it was likely to go aground, and then they were to pull it straight out into the stream again.

7280. When your float was lost in the fog very likely it did ground?—Where there has been any doubt about it that will be settled by contrast with previous experiments, but I do not think I have any evidence that it did ground.

7281. (*Mr. Webster.*) Just look at it with regard to these two tides; at the last tide, when it was observed upon the 9th of October, it was then just a little more than seven miles below the northern outfall?—That is so.

7282. Now it was next observed at high water the following tide, and it was then observed to be about $3\frac{3}{4}$ miles above the northern outfall?—The next tide that was so; it was only lost during the time that is shown by the dotted lines.

7283. It was observed to be at low water that same tide a little lower down, viz., $8\frac{3}{4}$ miles just above West Furlong Reach?—That is correct.

7284. Would that temporary loss of three hours, assuming it to be otherwise right, disturb the effect of the float experiment?—No, it is quite clear, looking at both the tops and bottoms of the ranges, that it was an accurate observation.

7285. Assuming that it was right at the end, and right at the beginning, do you think that three hours loss would have affected the experiment?—No.

7286. Even assuming it had been aground?—Even assuming it had been aground.

7287. (*Chairman.*) But the diagram shows it could not have been aground?—That is so; but assuming that it had been aground it had got in its right position again at the top of the next tide.

*Mr. B. Latham, M. Inst., C.E., F.G.S., F.M.S.*

23 Jan. 1883.

(*Mr. Webster.*) The dotted line is put in hypothetically, meaning that we do not know where that float was during that three hours; if it did get aground where the thick line ends, it must have floated off about the corresponding point of the flood, because we find it reaches the place it was expected to reach, having regard to the previous observations.

(*Chairman.*) That would, suppose it was out of sight, influx and reflux, but I understand the witness to say it was never out of sight more than three hours.

(*Mr. Webster.*) But the float is never out of sight in both the legs of the diagram. I submit that if the general float experiments are correct this particular error will not disturb the result.

7288. (*To the witness.*) You do not find, do you, any disturbing fluctuation in the diagram following that particular period of loss?—I do not; but even in this case the float was seen; it was reported as having been seen by a passing boat, and therefore we had knowledge with regard to the position of it at about low water.

7289. Will you tell us what the deduction from that No. 2 experiment is?—During the 31 days of observation the float advanced 1·3 miles down the river. That is taking one high water period as compared with another, because this No. 2 float was put in at half tide.

7290. At the end where was it? On the 18th of October, with regard to the beginning, was it 1·3 miles higher up the river?—It was 1·3 miles down the river at the high water periods, or 6·75 miles up the river at the half tide.

7291. At the corresponding half tide, when it ceased, where was it with regard to its position when it was put in; was it 1·3 miles higher up?—No; down the river. Then the report concludes by saying, "At the end of the two periods of lunation, ending "on the 16th of October, the float had ascended "1·33 miles up the river.

7292. What do you mean by a "lunation"?—Fourteen days.

7293. At the half tide, upon the 18th October, the corresponding tide, was it 1·3 miles above the point at which it was put in?—It had advanced 1·3 miles down the river at the corresponding period, that is to say, the next high water after it has gone down the river and up, because it is put in at half tide; and by comparing the period of high water with the high water at the end of the diagram, you will find it is 1·3 miles lower than at the commencement.

7294. But, at all events, at that half tide, it was 1·3 miles higher up?—I do not think that it was half tide when it was lost there.

(*Sir John Coode.*) I rather think you are speaking of a semi-lunation, while Mr. Webster is speaking of a full lunation.

(*Mr. Webster.*) Quite so. I ask you to deal first with a complete experiment.

(*Sir John Coode.*) I think the answer has been given with regard to a semi-lunation.

(*Witness.*) Taking it from the high water here to the other high water (*pointing to the diagram*), that is 1·30 lower down the river at the top of the tides.

7295. (*Chairman.*) At the end of the two periods of lunation, ending upon the 16th of October, the float had ascended the river by 1·33 miles, that is, it was a mile higher up the river than when it had started?—That is so; that is shown by comparing the two black lines.

7296. (*Mr. Webster.*) Will you tell us now what deduction you drew from float No. 3?—In 43 days it had made a progress from low water to low water of 13·80 miles down the river.

7297. At what time of the tide was that put in?—It was put in at low water.

7298. I may take it that you have put your deduction from these various experiments at the conclusion of the details of each experiment in your report?—I have.

7299. And you say those are correct?—I do.

7300. The first three floats are all put in on spring tides?—They were all put in when the tides were taking off after spring tides.

7301. Now, will you take No. 4 float?—No. 4 float was put in on high water at neap tide; No. 5 on half tide; and No. 6 on low water.

7302. Have you put the effect of your deductions also upon the diagrams?—The diagrams show everything with regard to the movements of the floats.

7303. Will you look at the last diagram of all in your book?—That refers to experiments which were made with regard to the mixing action; perhaps I ought to have explained the diagram which has been put in to show the influences which have been at work.

7304. With regard to the last diagram but one, does that show the phases of the moon?—Yes.

7305. And the direction of the wind?—Yes; these shaded columns represent the velocity of the wind at Greenwich, and the figures show the number of miles run (*pointing to the diagram*). The circles show the direction of the wind blowing from the periphery to the centre. The centre is supposed to be the head of the arrow; it is divided according to the two halves of the day, two circles for each day. The upper figure shows the quantity of water flowing every day in cubic feet per minute over Teddington Weir.

7306. This diagram shows wind force and direction, amount and condition of the tide, spring or neap, and the volume of water coming over Teddington Weir?—It does, and the phase of the moon.

7307. It also shows to the eye the amount of travel as well as distance in miles?—It shows the apparent vertical range of the tides by the figures at the bottom taken from the tidal record at Erith.

7308. What have you assumed in your subsequent calculations for turning the cubic feet into gallons?—If you multiply the number of cubic feet per minute by 9,000, that is to say, multiply it by nine, and add three cyphers, it gives the number of gallons in 24 hours.

7309. But what actual multiplier have you assumed for turning your cubic feet into gallons?—6¼.

7310. There were some simultaneous experiments also made which you call numbers 9 and 10, which are explained at pages 31 and 36 of the Report?—Yes, that is so. We should have made many more only the weather proved so rough. We tried to find whether there was any difference in the velocity of the tide in the various parts of the river.

(*After a short discussion*):

7311. I think you told the Commission a few minutes ago that you had also made some experiments for the purpose of testing the mixing operation?—Yes.

7312. Was that to ascertain whether the water was salt or fresh?—Those experiments were made with a view to applying practically the results that we had arrived at theoretically from the amount of chlorine that was found at various points.

7312*a*. That is to say, you tested various samples for chlorine, and from the result you could tell what the quality of the water was?—Yes.

(*Chairman.*) It would almost seem as though the effect of your observation was, that although owing to the mixing some water which went down might as it were be left, and other which had not gone down might be brought up, yet that taken as a whole no water had been discharged from the river during the 24 hours.

(*Mr. Webster.*) That is not quite so.

7313. (*Chairman.*) But your log went up higher than it went down?—Yes, but that is only the range of the tide during this time, but there was a current of upland water coming down, driving down everything before it.

(*After a short discussion*):

7314. (*Chairman.*) The log, if I understand, floated down and floated up, and its floating up, which must have been attributable to the action of the water, was

greater than its floating down ; was not that so ?—In some of the experiments it was, but not always.

(*Mr. Webster.*) In the first experiment it had gone down 1·7 miles, there are some in which it has gone down, and some in which it has gone up, but I do not think any deduction can be drawn to the effect that no water would have gone out.

7315. (*Chairman.*) You have told us of an entire lunation, that is to say, the moon beginning at one period of its age and going on till it reached the same period of age in the next; on that occasion the progression was up the river a trifle. I want to know whether I have rightly appreciated that?—That is, that the No. 2 float had gone up the river in the period in which it had been put in.

(*Mr. Webster.*) Your Lordship will be jumping to an erroneous conclusion if you take that view at the present moment. If I had gone through all the experiments in detail, you would have found many instances in which the float had progressed, for instance, 3·25 miles down the river ; and all I say is, that you cannot draw the abstract conclusion your Lordship does that the float necessarily worked upwards.

(*Chairman.*) I want to know if the witness will tell me how it could be, unless it were influenced by the wind or got stranded, that it would go up, which to my mind involves more water going up than going down.

(*Witness.*) At certain phases of the tide, when more water is coming into the river, that is, all the time that the tides are making,—the tendency is always for things to go higher up.

7316. That is because there is more water comes into the river than floats out ?—And at other periods when the tides are taking off, the tendency is for more water to flow out of the river, but this may be modified by the wind and the quantity of upland water coming down the river.

7317. But it could not be modified in this case by the quantity of water coming down the river, because the float went up, and if it is modified by the wind, it shows that the observation is to a certain extent fallacious.

(*Sir John Coode.*) When you speak of water going down the river, I take it that you refer only to the quantity of water flowing over Teddington Weir, and from the different tributaries of the Thames ?—Yes, that is so.

7318. (*Mr. Webster.*) May I put this question, as following upon his Lordship's. If you take one experiment and compare it with another, you sometimes find that it has gone up the river and sometimes you find it has gone down ?—Yes.

7319. Have you found, in the course of your investigation in this matter, that not unfrequently solid matter which sinks down to the bottom is found higher up the river than the point at which it was put in ?—There is no doubt that, owing to the superior influence of the flood tide, matters of a certain specific gravity can be picked up and carried to a certain point and there dropped, and the ebb tide will not carry them down again.

7320. (*Sir John Coode.*) Have you found it so ?—Yes.

7321. (*Chairman.*) I wished to know if I had rightly apprehended the witness's answer, and if so, what would be the explanation of the particular experiment. (*To the Witness.*) Suppose there had been no water over Teddington Lock at all, if it were an *impasse*, the log would simply float up and down except as it was affected by the wind, would not that be so ?—There seems to be a little misunderstanding with regard to this, because the ebb tides are much longer in their apparent flow than the flood tides, and if you take the relative velocity of each, you will find the velocity of the ebb is very much smaller than that of the flood. I find that the velocity of the flood tide is 192·2 feet per minute, while at the ebb tide it is 167·6 feet per minute.

7322. (*Chairman.*) The tide alongside of us at Westminster runs up for perhaps 5½ hours, and runs down for 7 hours ?—That would be so.

7323. But the log cannot outstrip the water in which it floats ?

(*Mr. Webster.*) Except it be for the wind.

(*Chairman.*) If it did it would be the most vivacious log that ever lived ; and if it cannot outstrip the water and is continually going up, the effect is that you have a river which does not discharge water into the sea, and is continually receiving water.

(*Witness.*) Except that the water may move with a varying velocity, the float would run past the water in one point, and the water would run past the float in another point. If there be a tendency to a greater flow of tidal water along the bed of the river, as is shown by experiment, by the greater amount of chlorine, then that has a tendency to accelerate the motion of the float up the river.

(*Chairman.*) Your main proposition, whether it goes a little higher or does not go quite so high, is, that as a matter of fact the sewage is oscillating between those two points.

(*Mr. Webster.*) I am very much obliged to your Lordship. I want your Lordship and the Commission to understand why we are introducing this matter at considerable length. The discussion which arose before the sewage was taken down to Barking at all was this. Where shall the outfall be ? I am not of course attacking the Metropolitan Board of Works. Then the advisers of the Board said, do not send us to Barking, it is much too far. There were other people who said, Barking is not far enough, and you will have to go very much further, or you will have to take the solids out of the sewage first. Then the wisdom of the time, parliamentary and otherwise, said, Barking will do. The idea at that time was that the sewage would practically be carried out to sea in one continuous stream, by always being discharged at the top of high water. I do not care a bit whether it is half a mile higher or lower. What we are seeking to prove is, that there is for a very long period of time an oscillating backwards and forwards between a point much lower than Barking, we will say Gravesend for instance, and a point higher up, of this sewage matter, and that the effect is to leave at the bottom of the river and to leave in the water that which either tends to a great nuisance or is a great nuisance. I am not at all suggesting that these float experiments prove more at present than that there is a washing backwards of sewage, and that it does not flow away readily. I quite admit that you can criticise the details of the experiments.

(*Mr. Bidder.*) If all my learned friend wants to prove is the general proposition, that the sewage does not go in one journey to sea, but oscillates backwards and forwards for an uncertain number of tides, then we are all agreed. Nobody suggests that it goes straight away to sea, but we are intending to show that the progress of the sewage to the sea is very much more rapid than anything he suggests. No one has ever suggested that the sewage would go continuously to the sea without oscillation.

7324. (*Mr. Webster to the witness.*) Did you have a float which went down continuously from Teddington to Southend, not being allowed to float up, but always going down with the ebb ?—We have had a float always going down with the ebb, and a corresponding float always coming up upon the flood.

7325. And did you take samples of the water so as to ascertain at various points at similar states of the tide what the amount of chlorine was ?—Yes, in No. 1 diagram the float was put in at Yantlet and a sample taken at the surface. In No. 1a a sample was taken at half the depth of the river, and the samples were submitted to the chemists for the purpose of ascertaining the amount of chlorine in the water (*explaining the diagram to the Commission*). There was such a powerful stream of upland water coming down the river that we could not get the float any higher up than that.

*Mr. B. Latham, M. Inst. C.E., F.G.S., F.M.C.*

23 Jan. 1883.

7326. What date are you referring to?—To the 4th of November.

7327. If you refer to page 55 of the report you will find that, upon the 3rd of November, 711,100 cubic feet per minute came over Teddington Weir; and, upon the 4th of November, 627,547 cubic feet per minute came over Teddington Weir; it has been higher, and it has been down as low as 74,279; that is on page 49; so that, on this occasion, a very large quantity of upland water was coming down?—A very large quantity of upland water was coming down, although there was a tidal wave passing through that water, there was no actual tidal current backwards.

7328. (*Chairman.*) You are three days getting from Yantlet Creek to the Commercial Docks, and you get to Yantlet Creek in three days from a little above the Commercial Docks?—Yes, that is the portion where there is the largest amount of tidal water in the river; but when we get higher up than that, we get a very slow progress upward.

7329. If the sewage had been discharged at Richmond, it would have left Richmond, and never come back again?—At those points where you have a considerable amount of upland water coming in, you have a greater flow downwards.

7330. The broader the river where the discharge is, the less rapid will be the passing away of the sewage, and the longer it will oscillate?—The more tidal water it contains in proportion to upland water the longer it will oscillate.

(*Mr. Webster.*) Your Lordship is dealing only with floating.

(*Chairman.*) Yes, and not with mixing, because the more tidal water there is the more it mixes.

(*Witness.*) Yes.

7331. (*Mr. Webster.*) You have put upon the diagram the amount of chlorine in the various samples?—Yes; this is the result of analyses by Professor Way.

7332. Have you put, in the shape of a table, the effect of the mixing, taking an area, and judging by the amount of chlorine the amount of river and sea water there was?—This was only done as a check, showing that the mode of calculation we adopted was correct. The actual calculations were made from samples carefully taken up and down the river.

7333. (*Mr. Bidder.*) You say there are figures upon the plan showing the amount of chlorine; they are not upon my copy?—I said they were upon my plan. I put them on the plan before the Commission for my own use. I will lend you my plan, and you can put them on to your plan.

7334. (*Mr. Webster.*) Have you put, in the shape of a table, the effect of the mixing action with regard to the water?—I have.

7335. Will you hand in a copy of that table? *The tables were handed in.* (*See pages* 212, 213.)

7336. Are the red figures you have put on taken from Professor Way's analyses?—They are taken from Professor Way's analyses of the water going up the river upon that day.

7337. Does this table show the result of the experiments and the effect of the mixing, as you have tested it, after your calculations upon three days, the 14th and 22nd of September, and the 30th of November?—It does.

7338. I will take them separately; first, I want to know what was the condition of the Thames upon the 14th of September with regard to upland water; that I think the Commissioners will find at page 49 of your first Report; there were 83,327 cubic feet per minute passing over Teddington Weir, is that correct?—Yes.

7339. Then that would be a low period of upland water?—A moderate period, not a low period, we have had no low water this year.

7340. Taking the high water, the first thing to observe with regard to all the tables is the head note at the beginning: "The results are obtained by taking sewage as containing 10, river water 1·7, and sea water 1961 parts of chlorine in 100,000 parts. The numbers of days are calculated from the gaugings of the total flow of the River Thames on each day." The first column gives, does it not, the places to which the various mixing experiments or testings apply?—Yes, it does.

7341. Does the second column give the cross section of the river?—It does, at high water.

7342. Was this a spring or a neap tide?—That is a spring tide.

7343. The next column shows the quantity of sea water shown by analysis?—This is the quantity of sea water which is deduced from the amount of chlorine in the water, which occupies a number of feet of the section; that is to say, taking a section one foot in length it would occupy one foot in length of the whole section; at Teddington it is all river water.

(*Chairman.*) Sewage water is assumed to have chlorine in it; then it says river water and sewage combined 2518 square feet, and yet there was no chlorine.

(*Mr. Webster.*) Only the chlorine which would be represented by river water and sewage combined.

7344. (*Chairman.*) There was no chlorine in the water at all, so you infer from that that there was no sea water?—There was the chlorine in it that was due to the river water and sewage.

(*Mr. Bidder.*) Upon the head of the table it is said the sewage is assumed as containing 10 parts, and the river water 1·7: now it occurs to me that before you could arrive at any conclusion as to the proportion of river water and sewage combined, you must have arrived at some conclusion with regard to the amount of river water and the amount of sewage.

7345. (*Mr. Webster.*) We are dealing with it as a matter of comparison in each case, but with regard to the 2518 square feet, what do you assume to have been the condition as regards sewage and river water?—Our standard of 1·7 is the quantity of chlorine in the water which really comes over Teddington weir, and is assumed to be the initial quantity due to the river.

7346. (*Sir John Coode.*) Ascertained by direct experiment?—Ascertained by direct experiment from a large number of samples submitted to the chemists.

7347. 1·7 is the mean of the whole?—1·7 is the mean of the whole.

7348. (*Mr. Webster.*) That water has, when it comes over Teddington Weir, some sewage in it?—I do not say that it has any sewage in it, but it has some chlorine.

7349. (*Mr. Bidder.*) At Chiswick you find more chlorine; suppose you find three or four parts instead of 1·7, how do you know whether the extra one or two parts are caused by a very little sea water or a great deal of sewage, because either would account for it?—We have very carefully shown that, and I may say we have taken all through these experiments a standard quantity of sewage containing 10 parts in 100,000 at 5 cubic feet per head of the population; therefore we know every day what proportion that quantity bears to the volume of water coming down the river every day, and where we see that there is chlorine carried up as far as Chiswick, we have had to make a very careful calculation and show what would be the amount due to sea water, and what due to sewage, because we take it for granted that wherever sea water is carried up past the outfalls, there sewage might be carried past.

7350. (*Chairman.*) I understand from the table which is before me that there is chlorine at Chiswick and that there is a great deal more at St. Paul's Pier, and still more at Deptford, and that the inference to be drawn from that is that salt water has got up to the place where chlorine is found; is that so?—That is so.

7351. Then Mr. Bidder asked "Is not there chlorine in sewage"?—There is, but nothing like the proportion that is found in sea water. If sewage were mixed with fresh water only at any of these points, it

would not give anything like the quantity that is found there upon a particular day.

(*Mr. Webster.*) There is 196 times as much in the sea water as there is in the sewage.

(*Witness.*) There was about eight times as much river water coming down upon that day as there was sewage going in; therefore if you mix them in proportion taking eight parts of fresh water and only one part, of sewage it would not make any very great difference in the mixed volume.

7352. You would only get $1\frac{1}{4}$ to the 100,000 parts?—Between 2 and 3.

7353. A given quantity of sewage comes into the Thames every day, a given quantity of sea water comes into the Thames every day, and we will assume upon a particular day a given quantity of fresh water; the sea water contains so much chlorine, and the fresh water contains so much chlorine, and sewage is assumed to contain 10 parts of chlorine. If your Lordship assumed it all went together to a particular point you ought to be able to get approximately at the composition of the mixture at that point. Now the witness has worked backwards. Taking the sewage admittedly due to the metropolis, and coming into the river at certain points, and taking the sea water and the fresh water and ascribing to those elements the relative proportion of chlorine put down in the heading of the table, what proportion of chlorine is shown to be in the mixture that is obtained. I do not say it is shown absolutely, but it is capable of reasonably fair precision.

7354. (*Chairman.*) You say there could not be the quantity of chlorine that there was at any particular place unless the salt water had got up there?—Precisely so.

7355. (*Mr. Webster.*) Of course it almost follows that in order to make your fourth column of river water and sewage water combined, you must have an idea of the amount of river water in the river and the amount of sewage in the river?—That is so.

7356. The next column merely gives the proportion of river water and sewage to the sea water?—It is the ratio of those two columns.

7357. The next column gives the lineal distance in feet?—Yes, the next column gives the lineal distance in feet from one station to another; from Teddington to Chiswick is the first one.

7358. (*Chairman.*) At St. Paul's pier it is about eight to one?—8·4 to one is the ratio.

7359. (*Mr. Webster.*) Now the next column is the mean sectional area of river water and sewage combined; that is simply adding together the sectional area at Chiswick and Teddington, deducting the quantity occupied by sea water and dividing it by two?—Yes, that is so; it is the mean sectional area occupied by river water and sewage combined.

*Mr. B. Latham, M. Inst. C.E., F.G.S., F.M.C.*

23 Jan. 1883.

7360. Now the next is, "Time occupied by fresh "water and sewage in traversing the river": how is that got out?—That is, assuming a particle of sewage were put in at Teddington, it would take 1·71 days to travel through the sectional area which is shown in the preceding column, to Chiswick.

7361. I want to know whether the 1·71 days occupied in going from Teddington to Chiswick is a calculation?—It is a calculation based upon the capacity of the section of the river, and the total quantity of water coming down the river. These tables were compiled in a very great hurry, and they are not absolutely correct as they ought to have been calculated, upon the quantity of water coming in at different parts of the river, but I have since corrected them.

7362. This table assumes that there is no fresh water coming in below Teddington?—That is so; that it all comes in at Teddington.

7363. Whereas, as a matter of fact, it comes in at various points all down the river?—It does.

7364. In the condition of spring tide, what time would it take that particle to get from Barking to Southend?—30 days.

7365. A similar calculation is due to the low water in the time table?—Yes.

7366. That, I think, makes it from Barking to Southend 31 days?—31 days.

7367. Now will you turn to the 22nd of September, and tell us what was the condition of the river upon the 22nd of September?—Upon the 22nd of September there is about 50 per cent. more upland water in the river than upon the 14th of September.

7368. The difference is between 83 and 122?—Yes, but I take the totals at the bottom; this is worked upon the 157,745 cubic feet per minute.

7369. That is, assuming the water coming down at 157,745 feet, which you have treated as all coming in at Teddington?—Yes, and I have a table here in which that is corrected. *This table was handed in.* (*See pages* 214, 215.)

*Mr. B. Latham, M. Inst. C.E., F.G.S., F.M.C.*

23 Jan. 1883.

TABLE showing the EFFECT of the MIXING ACTION in the RIVER THAMES.

The results are obtained by taking sewage as containing 10, river water 1·7, and sea water 1,961 parts of chlorine in 100.000 parts. The number of days is calculated from the gaugings of the total flow of the River Thames on each day. In this case all the upland water is assumed to enter the river at Teddington.

HIGH WATER. September 14th, 1882.

| Place. | Area of Cross Section. | Area of Cross Section occupied by: Sea Water. | Area of Cross Section occupied by: River Water and Sewage combined. | Ratio of River Water and Sewage combined to Sea Water. | Distance. | Mean Sectional Area of River Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. |
|---|---|---|---|---|---|---|---|---|
| | Sq. Feet. | Sq. Feet. | Sq. Feet. | | Feet. | Sq. Feet. | Days. | Days. |
| Teddington - | 2,518 | 0 | 2,518 | All river water. | 48,405 | 6,002 | 1·71 | 1·71 |
| Chiswick - | 9,500 | 14 | 9,486 | 652·0 | 48,389 | 14,464 | 4·11 | 5·82 |
| St. Paul's Pier - | 21,758 | 2,317 | 19,441 | 8·4 | 24,874 | 23,134 | 3·38 | 9·20 |
| Deptford - | 34,501 | 7,674 | 26,827 | 3·5 | 29,188 | 28,639 | 4·91 | 14·11 |
| North Woolwich | 46,229 | 15,778 | 30,451 | 1·93 | 9,156 | 35,652 | 1·92 | 16·03 |
| Barking - - | 65,791 | 24,939 | 40,852 | 1·64 | 13,620 | 40,433 | 3·24 | 19·27 |
| Crossness - | 75,130 | 35,116 | 40,014 | 1·14 | 14,227 | 43,000 | 3·59 | 22·86 |
| Erith - - | 96,835 | 50,849 | 45,986 | 0·904 | 51,570 | 39,906 | 12·09 | 34·95 |
| Gravesend - | 144,323 | 110,496 | 33,827 | 0·306 | 90,081 | 22,468 | 11·89 | 46·84 |
| Southend - | 725,111 | 714,003 | 11,108 | 0·015 | | | | |

HIGH WATER. September 22nd, 1882.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Teddington - | 1,624 | 0 | 1,624 | All river water. | 48,405 | 4,353 | 0·93 | 0·93 |
| Chiswick - | 7,082 | 0 | 7,082 | „ | 48,389 | 12,019 | 2·56 | 3·49 |
| St. Paul's Pier - | 17,744 | 788 | 16,956 | 21·5 | 24,874 | 20,882 | 2·29 | 5·78 |
| Deptford - | 29,453 | 4,644 | 24,809 | 5·34 | 29,188 | 26,638 | 3·41 | 9·19 |
| North Woolwich | 40,405 | 11,937 | 28,468 | 2·38 | 9,156 | 33,623 | 1·36 | 10·55 |
| Barking - - | 57,409 | 18,630 | 38,779 | 2·08 | 13,620 | 39,597 | 2·37 | 12·92 |
| Crossness - | 65,581 | 25,166 | 40,415 | 1·60 | 14,227 | 44,106 | 2·76 | 15·68 |
| Erith - - | 87,085 | 39,287 | 47,798 | 1·22 | 51,570 | 44,237 | 10·04 | 25·72 |
| Gravesend - | 130,816 | 90,140 | 40,676 | 0·45 | 90,081 | 31,771 | 12·60 | 38·32 |
| Southend - | 639,819 | 616,952 | 22,867 | 0·037 | | | | |

HIGH WATER. November 30th, 1882.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Teddington - | 2,489 | 0 | 2,489 | All river water. | 48,405 | 5,762 | 0·35 | 0·35 |
| Chiswick - | 9,035 | 0 | 9,034 | 7836·2 | 48,389 | 14,813 | 0·89 | 1·24 |
| St. Paul's Pier - | 20,602 | 11 | 20,591 | 1780·1 | 24,874 | 26,538 | 0·82 | 2·06 |
| Deptford - | 32,791 | 305 | 32,486 | 106·0 | 29,188 | 37,057 | 1·35 | 3·41 |
| North Woolwich | 44,258 | 2,629 | 41,629 | 15·8 | 9,156 | 49,889 | 0·57 | 3·98 |
| Barking - - | 62,983 | 4,834 | 58,149 | 12·0 | 13,620 | 6,0186 | 0·02 | 5·00 |
| Crossness - | 72,346 | 10,122 | 62,224 | 6·14 | 14,227 | 70,321 | 1·25 | 6·25 |
| Erith - - | 93,293 | 14,874 | 78,419 | 5·27 | | | | |
| Gravesend - | 137,666 | No samples taken | | | 141,651 | 70,167 | 12·39 | 18·64 |
| Southend - | 689,202 | 627,286 | 61,916 | 0·098 | | | | |

*Mr. B. Latham. M. Inst. C.E., F.G.S., F.M.S.*

23 Jan. 1883.

TABLE showing the EFFECT of the MIXING ACTION in the RIVER THAMES—*continued.*

The results are obtained by taking sewage as containing 10, river water 1·7, and sea water 1,961 parts of chlorine in 100,000 parts. The number of days is calculated from the gaugings of the total flow of the River Thames on each day. In this case all the upland water is assumed to enter the river at Teddington.

LOW WATER. September 14th, 1882.

| Place. | Area of Cross Section. | Area of Cross Section occupied by | | Ratio of River Water and Sewage combined to Sea Water. | Distance. | Mean Sectional Area of River Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. |
|---|---|---|---|---|---|---|---|---|
| | | Sea Water. | River Water and Sewage combined. | | | | | |
| | Sq. Feet. | Sq. Feet. | Sq. Feet. | | Feet. | Sq. Feet. | Days. | Days. |
| Teddington - | 806 | 0 | 806 | All river water. | 48,405 | 1,812 | 0·51 | 0·51 |
| Chiswick - | 2,818 | 0 | 2,818 | „ | 48,389 | 4,727 | 1·34 | 1·85 |
| St. Paul's Pier - | 6,643 | 7 | 6,636 | 983·0 | 24,874 | 9,627 | 1·41 | 3·26 |
| Deptford - | 12,927 | 308 | 12,619 | 40·9 | 29,188 | 14,827 | 2·54 | 5·80 |
| North Woolwich | 18,731 | 1,697 | 17,034 | 10·0 | 9,156 | 19,875 | 1·07 | 6·87 |
| Barking - - | 27,094 | 4,377 | 22,717 | 5·19 | 13,620 | 22,907 | 1·84 | 8·71 |
| Crossness - | 30,337 | 7,239 | 23,098 | 3·19 | 14,227 | 28,772 | 2·40 | 11·11 |
| Erith - - | 47,142 | 12,695 | 34,447 | 2·71 | 51,570 | 35,622 | 6·81 | 17·92 |
| Gravesend - | 79,801 | 43,005 | 36,796 | 0·85 | 90,081 | 37,640 | 19·93 | 37·85 |
| Southend - | 384,510 | 346,026 | 38,484 | 0·11 | | | | |

LOW WATER. September 22nd, 1882.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Teddington - | 977 | 0 | 977 | All river water. | 48,405 | 1,975 | 0·42 | 0·42 |
| Chiswick - | 2,974 | 0 | 2,974 | „ | 48,389 | 5,559 | 1·18 | 1·60 |
| St. Paul's Pier - | 8,146 | 2 | 8,144 | 4·451 | 24,874 | 11,515 | 1·26 | 2·86 |
| Deptford - | 15,091 | 205 | 14,886 | 73·5 | 29,188 | 17,695 | 2·27 | 5·13 |
| North Woolwich | 22,324 | 1,820 | 20,504 | 11·2 | 9,156 | 23,941 | 0·96 | 6·09 |
| Barking - - | 31,899 | 4,521 | 27,378 | 6·05 | 13,620 | 28,014 | 1·68 | 7·77 |
| Crossness - | 36,892 | 8,242 | 28,650 | 3·47 | 14,227 | 33,999 | 2·13 | 9·90 |
| Erith - - | 54,812 | 15,464 | 39,348 | 2·54 | 51,570 | 40,445 | 9·18 | 19·08 |
| Gravesend - | 90,503 | 48,961 | 41,542 | 0·85 | 90,081 | 36,162 | 14·34 | 33·42 |
| Southend - | 415,800 | 385,018 | 30,782 | 0·08 | | | | |

LOW WATER. November 30th, 1882.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Teddington - | 1,877 | 0 | 1,877 | All river water. | 48,405 | 2,851 | 0·17 | 0·17 |
| Chiswick - | 3,825 | 0 | 3,825 | „ | 48,389 | 5,617 | 0·34 | 0·51 |
| St. Paul's Pier - | 7,410 | 0 | 7,410 | „ | 24,874 | 10,155 | 0·31 | 0·82 |
| Deptford - | 12,900 | 0 | 12,900 | „ | 29,188 | 15,852 | 0·58 | 1·40 |
| North Woolwich | 18,817 | 13 | 18,804 | 1398·5 | 9,156 | 22,990 | 0·26 | 1·66 |
| Barking - | 27,219 | 43 | 27,176 | 631·0 | 13,620 | 29,247 | 0·49 | 2·15 |
| Crossness - | 31,590 | 272 | 31,318 | 115·2 | 14,227 | 38,612 | 0·68 | 2·83 |
| Erith - - | 47,908 | 2,001 | 45,907 | 22·9 | | | | |
| Gravesend - | 80,578 | No samples taken | | | 141,651 | 65,617 | 11·58 | 14·41 |
| Southend - | 381,220 | 295,893 | 85,327 | 0·29 | | | | |

*Mr. B. Latham, M. Inst. C.E., F.G.S., F.M.S.*

23 Jan. 1883.

TABLE showing the EFFECT of the MIXING ACTION in the RIVER THAMES.

The results are obtained by taking sewage as containing 10, river water 1·7, and sea water 1,961 parts of chlorine in 100,000 parts. In this case the upland water is apportioned to every section of the river which it enters.

HIGH WATER. September 14th, 1882.

| Place. | Area of Cross Section. | Area of Cross Section occupied by: Sea Water. | Area of Cross Section occupied by: River Water and Sewage combined. | Ratio of River Water and Sewage combined to Sea Water. | Distance. | Mean Sectional Area of River Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. | Apportioned Flow of River Thames. |
|---|---|---|---|---|---|---|---|---|---|
| | Sq. Feet. | Sq. Feet. | Sq. Feet. | | Feet. | Sq. Feet. | Days. | Days. | Cub. Feet per Min. |
| Teddington - | 2,518 | 0 | 2,518 | All river water. | 48,405 | 6,002 | 2·38 | 2·38 | 84,543 |
| Chiswick - | 9,500 | 14 | 9,486 | 652·0 | 48,389 | 14,464 | 5·61 | 7·99 | 86,609 |
| St. Paul's Pier - | 21,758 | 2,317 | 19,441 | 8·4 | 24,874 | 23,134 | 4·56 | 12·55 | 87,574 |
| Deptford - | 34,501 | 7,674 | 26,827 | 3·5 | 29,188 | 28,639 | 6·52 | 19·07 | 89,004 |
| North Woolwich | 46,229 | 15,778 | 30,451 | 1·93 | 9,156 | 35,652 | 2·47 | 21·54 | 91,570 |
| Barking - - | 65,791 | 24,939 | 40,852 | 1·64 | 13,620 | 40,433 | 3·78 | 25·32 | 101,057 |
| Crossness - | 75,130 | 35,116 | 40,014 | 1·14 | 14,227 | 43,000 | 3·88 | 29·20 | 109,439 |
| Erith - - | 96,835 | 50,849 | 45,986 | 0·904 | 51,570 | 39,906 | 12·70 | 41·90 | 112,535 |
| Gravesend - | 144,323 | 110,496 | 33,827 | 0·306 | 90,081 | 22,468 | 12·03 | 53·93 | 116,822 |
| Southend - | 725,111 | 714,003 | 11,108 | 0·015 | | | | | |

HIGH WATER. September 22nd, 1882.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Teddington - | 1,624 | 0 | 1,624 | All river water. | 48,405 | 4,353 | 1·18 | 1·18 | 123,550 |
| Chiswick - | 7,082 | 0 | 7,082 | „ | 48,389 | 12,019 | 3·22 | 4·40 | 125,504 |
| St. Paul's Pier - | 17,744 | 788 | 16,956 | 21·5 | 24,874 | 20,882 | 2·85 | 7·25 | 126,420 |
| Deptford - | 29,453 | 4,644 | 24,809 | 5·34 | 29,188 | 26,638 | 4·19 | 11·44 | 128,801 |
| North Woolwich | 40,405 | 11,937 | 28,468 | 2·38 | 9,156 | 33,623 | 1·61 | 13·05 | 132,410 |
| Barking - - | 57,409 | 18,630 | 38,779 | 2·08 | 13,620 | 39,597 | 2·64 | 15·69 | 141,942 |
| Crossness - | 65,581 | 25,166 | 40,415 | 1·60 | 14,227 | 44,106 | 2·89 | 18·58 | 150,423 |
| Erith - - | 87,085 | 39,287 | 47,798 | 1·22 | 51,570 | 44,237 | 10·37 | 28·95 | 152,833 |
| Gravesend - | 130,816 | 90,140 | 40,676 | 0·45 | 90,081 | 31,771 | 12·71 | 41·66 | 156,380 |
| Southend - | 639,819 | 616,952 | 22,867 | 0·037 | | | | | |

HIGH WATER. November 30th, 1882.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Teddington - | 2,489 | 0 | 2,489 | All river water. | 48,405 | 5,762 | 0·40 | 0·40 | 480,677 |
| Chiswick - | 9,035 | 1 | 9,034 | 7836·2 | 48,389 | 14,813 | 1·02 | 1·42 | 487,260 |
| St. Paul's Pier - | 20,602 | 11 | 20,591 | 1780·1 | 24,874 | 26,538 | 0·93 | 2·35 | 489,715 |
| Deptford - | 32,791 | 305 | 32,486 | 106·0 | 29,188 | 37,057 | 1·50 | 3·85 | 500,049 |
| North Woolwich | 44,258 | 2,629 | 41,629 | 15·8 | 9,156 | 49,889 | 0·61 | 4·46 | 513,612 |
| Barking - - | 62,983 | 4,834 | 58,149 | 12·0 | 13,620 | 60,186 | 1·08 | 5·54 | 527,587 |
| Crossness - | 72,346 | 10,122 | 62,224 | 6·14 | 14,227 | 70,321 | 1·29 | 6·83 | 539,543 |
| Erith - - | 93,293 | 14,874 | 78,419 | 5·27 | | | | | |
| Gravesend - | 137,666 | No samples taken. | | | 141,651 | 70,167 | 12·57 | 19·40 | 549,089 |
| Southend - | 689,202 | 627,286 | 61,916 | 0·098 | | | | | |

*Mr. B. Latham, M. Inst. C.E. F.G.S., F.M.S.*

23 Jan. 1883.

TABLE showing the EFFECT of the MIXING ACTION in the RIVER THAMES.

The results are obtained by taking sewage as containing 10, river water 1·7, and sea water 1,961 parts of chlorine in 100,000 parts. In this case the upland water is apportioned to every section of the river which it enters.

LOW WATER. September 14th, 1882.

| Place. | Area of Cross Section. | Area of Cross Section occupied by | | Ratio of River Water and Sewage combined to Sea Water. | Distance. | Mean Sectional Area of River Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. | Apportioned Flow of River Thames. |
|---|---|---|---|---|---|---|---|---|---|
| | | Sea Water. | River Water and Sewage combined. | | | | | | |
| | Sq. Feet. | Sq. Feet. | Sq. Feet. | | Feet. | Sq. Feet. | Days. | Days. | Cub. Feet per Min. |
| Teddington - | 806 | 0 | 806 | All river water. | 48,405 | 1,812 | 0·72 | 0·72 | 84,543 |
| Chiswick - | 2,818 | 0 | 2,818 | „ | 48,389 | 4,727 | 1·83 | 2·55 | 86,609 |
| St. Paul's Pier - | 6,643 | 7 | 6,636 | 983·0 | 24,874 | 9,627 | 1·90 | 4·45 | 87,574 |
| Deptford - | 12,927 | 308 | 12,619 | 40·9 | 29,188 | 14,827 | 3·37 | 7·82 | 89,004 |
| North Woolwich | 18,731 | 1,697 | 17,034 | 10·0 | 9,156 | 19,875 | 1·38 | 9·20 | 91,570 |
| Barking - - | 27,094 | 4,377 | 22,717 | 5·19 | 13,620 | 22,907 | 2·14 | 11·34 | 108,057 |
| Crossness - | 30,337 | 7,239 | 23,098 | 3·19 | 14,227 | 28,772 | 2·60 | 13·94 | 109,489 |
| Erith - - | 47,142 | 12,695 | 34,447 | 2·71 | 51,570 | 35,622 | 11·33 | 25·27 | 112,535 |
| Gravesend - | 79,801 | 43,005 | 36,796 | 0·85 | 90,081 | 37,640 | 20·15 | 45·42 | 116,822 |
| Southend - | 384,510 | 346,026 | 38,484 | 0·11 | | | | | |

LOW WATER. September 22nd, 1882.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Teddington - | 977 | 0 | 977 | All river water. | 48,405 | 1,975 | 0·53 | 0·53 | 123,550 |
| Chiswick - | 2,974 | 0 | 2,974 | „ | 48,389 | 5,559 | 1·49 | 2·02 | 125,504 |
| St. Paul's Pier - | 8,146 | 2 | 8,144 | ,4451 | 24,874 | 11,515 | 1·57 | 3·59 | 126,420 |
| Deptford - | 15,091 | 205 | 14,886 | 73·5 | 29,188 | 17,695 | 2·78 | 6·37 | 128,801 |
| North Woolwich | 22,324 | 1,820 | 20,504 | 11·2 | 9,156 | 23,941 | 1·15 | 7·52 | 132,410 |
| Barking - - | 31,899 | 4,521 | 27,378 | 6·05 | 13,620 | 28,014 | 1·86 | 9·38 | 141,942 |
| Crossness - | 36,892 | 8,242 | 28,650 | 3·47 | 14,227 | 33,999 | 2·23 | 11·61 | 150,423 |
| Erith - - | 54,812 | 15,464 | 39,348 | 2·54 | 51,570 | 40,445 | 9·48 | 21·09 | 152,833 |
| Gravesend - | 90,503 | 48,961 | 41,542 | 0·85 | 90,081 | 36,162 | 14·46 | 35·55 | 156,380 |
| Southend - | 415,800 | 385,018 | 30,782 | 0·08 | | | | | |

LOW WATER. November 30th, 1882.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Teddington - | 1,877 | 0 | 1,877 | All river water. | 48,405 | 2,851 | 0·20 | 0·20 | 480,677 |
| Chiswick - | 3,825 | 0 | 3,825 | „ | 48,389 | 5,617 | 0·39 | 0·59 | 487,260 |
| St. Paul's Pier - | 7,410 | 0 | 7,410 | „ | 24,874 | 10,155 | 0·36 | 0·95 | 489,715 |
| Deptford - | 12,900 | | 12,900 | „ | 29,188 | 15,852 | 0·64 | 1·59 | 500,049 |
| North Woolwich | 18,817 | 13 | 18,804 | 1398·5 | 9,156 | 22,990 | 0·28 | 1·87 | 513,612 |
| Barking - - | 27,219 | 43 | 27,176 | 631·0 | 13,620 | 29,247 | 0·52 | 2·39 | 527,537 |
| Crossness - | 31,590 | 272 | 31,318 | 115·2 | 14,227 | 38,612 | 0·70 | 3·09 | 539,543 |
| Erith - - | 47,908 | 2,001 | 45,907 | 22·9 | | | | | |
| Gravesend - | 80,578 | No samples taken. | | | 141,651 | 65,617 | 11·75 | 14·84 | 549,089 |
| Southend - | 381,220 | 295,893 | 85,327 | 0·29 | | | | | |

*Mr. B. Latham, M. Inst. C.E., F.G.S., F.M.S.*

23 Jan. 1883.

(*Sir John Coode.*) About what is the relation of the water coming in at Teddington Weir to the whole volume of fresh water delivered into the Thames.

*Mr. Webster* stated that that would be found in the report at page 49.

7370. (*Mr. Webster.*) For the purpose of the experiment of the 22nd of September, you have given the whole of the water as 157,745 cubic feet, which is shown in the last column at page 49?—Yes.

7371. And you have again treated that as coming in at Teddington?—Yes.

7372. And you put that down as being 50 per cent. over what came in upon the 14th of September?—Yes.

7373. And upon what tide was that?—That was upon a neap tide.

7374. From Barking to Southend would take 28 days at high water?—27½ days.

7375. And from Barking to Southend at low water about 27 days?—Nearly 27½ days.

7376. Now will you please go to the 30th of November. What was the condition of the upland water upon that day?—The river was in flood upon the 30th of November.

7377. Was the tide spring or neap?—The tide was a neap tide.

7378. The total quantity of water coming into the river on that day is estimated at 557,000 cubic feet per minute as against 157,000 on the 22nd of September?—That is so.

7379. And that again you have treated as all coming in at Teddington?—Yes.

7380. How does that alter the calculation, how many days would it be from Barking to Southend under those circumstances?—14½ days at high water.

7381. And at low water?—About 13 days.

7382. Had you considered the question of mixing before you took these chlorine experiments?—Yes, these were tests taken to see whether the original samples which were taken upon these previous days would confirm our view as to this change going on all through the river.

7383. I will first take the average condition of the upland water.

(*Mr. Bidder.*) In every case the absolute quantity of sewage at Crossness where there were both outfalls coming in is less than at Barking where there was only one, and the ratio of sea water very much less although in one case you have one outfall, and at the other you have two.

(*Mr. Webster.*) You are wrong about that.

(*Sir John Coode.*) These are simply areas.

(*Mr. Bidder.*) If I understand rightly, the columns under the head of "Area of cross section occupied by "water and sewage combined," represent in each place the area of the river that will be occupied by sewage and river water at that point, and if you look at Barking and Crossness it shows that there is a less area occupied by sewage and river water at the lower place where there are two outfalls than at the upper one where there is only one.

(*Witness.*) It is simply due to this fact that there is a constriction in the cross-section of the channel at that point.

7384. (*Sir John Coode.*) Those are simply the relative areas of the river at those different points?—Yes, occupied by the different waters at these points.

7385. Apart from the composition of the water those are sectional areas of the river?—Yes.

(*Chairman.*) I am afraid also I cannot understand it.

(*Mr. Bidder.*) In addition, the next column shows the ratio of river water and sewage to salt water as diminished.

7326. (*Chairman to the witness.*) The area of the cross-section we may take to be arrived at by putting an imaginary division a foot in width across the river, and then seeing what the area of that is, not the content, but the superficial area?—Yes.

7327. Then you say, judging from the quantity of chlorine in it, which is furnished in certain proportions by fresh water, and in certain proportions by sewage, and in certain proportions by salt water, that at Barking out of a total quantity of 65,791 square feet, which you have represented as being there, there are 40,852 of sewage and river water combined?—That is so.

7328. Then when you get down to Crossness the area there is pretty nearly the same thing, but there has been a supply of more sewage and consequently more chlorine, I suppose?—There has been more sewage and a considerably larger quantity of sea water.

7389. How does that appear?—The chlorine tests show that.

7390. That is Mr. Bidder's difficulty as I understand, you have only 3,000 square or cubic feet of additional water altogether?—That is so.

7391. But you have 8,000 feet more of sea water, and you have also had an influx of sewage water?—That is quite true, but the sea water is to that extent in larger quantity there.

(*Mr. Webster.*) We are not dealing with the quantity in gallons at all, we are simply dealing with the proportion of area occupied.

7392. (*Chairman.*) In order to get the proportions, you will have to find the actual volume?—In order to get the proportion at any given time, all you want to know is the composition of the water at that time. There appears to be a constriction at Crossness by which the area is very much modified.

7393. (*Mr. Bidder.*) But your table shows a larger area?—At Crossness at low water upon the opposite table you will see that the section is absolutely smaller.

(*Chairman.*) Of course it is desirable that we should see that there is no mistake in these calculations: here again your case is not that 2317 is the right figure anywhere in particular, but that the experiments show that there is a quantity of salt water at St. Paul's Pier for example, and some at Chiswick.

(*Mr. Webster.*) That is perfectly right, but all I am going to say about this, is, that the only point for which I shall use this table is to show that there is going on between Chiswick and Southend a mixing, and that it is not right to say that that sewage which is poured out by the Metropolitan Board of Works is always going backwards and forwards, but that it is becoming diluted, and that helps to remedy the evil.

(*Chairman.*) I presume Mr. Bidder would admit that there is and must be a mixing action.

(*Mr. Bidder.*) Of course I do.

(*Mr. Webster.*) I was going on to say that your Lordship has had no statement of ours, and I do not in the least wish to make one. We are only endeavouring to see what the effect of turning out the sewage at Barking is, but we shall prove some day that due to this washing up and down, there is left deposited at the bottom of the river a large quantity of solid matter from the sewage which gives off offensive gas, and that there is also in suspension in the river a large quantity of particles which give off noxious gases and smells. I agree that it is a question of degree; it may be that we are showing a nuisance growing up so to speak, that the system has already developed in many places a very great nuisance, and in other places that it is growing up. I am not suggesting that we can prove, either mathematically or to demonstration, what the actual age of the deposit would be, but all our observations point to this, that close by the outfall you have a very large deposit, and as you recede from it, you find similar deposits of sewage matter showing that the same result which used to go on up in London years ago, and was then complained of as prejudicial to the river, is now being carried on further down.

(*Chairman.*) Let us proceed with the evidence.

7394. (*Mr. Webster to the witness.*) Taking the average condition of the river, what do you say is about the average quantity of fresh water coming in?—I take it at about 30 cubic feet per minute per square mile of drainage area.

7395. Will you point that out in your book?—The quantity coming down upon the 22nd of September would represent very nearly the average.

7396. That would represent 157,000 cubic feet a minute, of which 122,000 came over their weir?—Yes.

7397. And in dry weather what would it go down to?—In dry weather it would go down to 12 feet per minute per square mile over the whole area, from 30 to 12.

7398. That would practically speaking take the 150,000 down to 60,000.

(*Chairman.*) 5,000 square miles, multiplied by 30, would give 150,000 cubic feet a minute, or, multiplied by 12, would give 60,000.

7399. (*Mr. Webster.*) At page 49 of the Report you say that there was coming in on the 22nd of September, 157,745 cubic feet per minute?—There was.

7400. Which corresponds approximately with the 150 which my Lord worked out just now?—It does.

7401. Of that, according to your judgment, 122,461 came over Teddington Weir?—That was the actual quantity measured as coming over.

7402. The remainder coming in by the other tributaries between Teddington Weir and Barking?—That is so, only that you will see the water supply is added at the bottom, though it really belongs to the top.

7403. How low would that go down in dry times?—That, as I have said, would go down to 12 cubic feet per minute.

7404. I believe there is no day in this table which is down to a drought period?—Nothing like it.

7405. What would a flood come to?—In a maximum flood, the quantity would be 360 cubic feet per minute from a square mile.

7406. That is about twelve times as much as the average, and that though not the full amount is approximately shown on page 55, the 30th October?—That is twelve times the mean flow, and it is thirty times the minimum flow. The biggest one that we have gauged is, as you point out, upon the 30th of October.

7407. That is 1,304,000 upon the whole; is that correct?—Yes.

7408. Of which 1,053,000 comes over Teddington Weir?—That is correct.

7409. Take Barking, the northern outfall, within what time do you think on an ordinary average flow, effluent sewage is carried out to sea by both floating and mixing combined, that is to say, during an ordinary 30 cubic feet a minute period?—It would be a very much longer time as is shown by the ratio between these results.

7410. I only want to know whether you have formed a judgment as to the average time?—It is almost impossible, without experiment, to know for certain.

7411. In a dry time you can give it us by taking the 14th September?—The dryest one of these experiments was on the 14th of September.

7412. What time would it take in the dryest period?—It would be more than is represented in the table.

7413. In flood time how soon would it go out?—In flood time it would go out very quickly indeed, probably in a week.

7414. I think you have already put together, for use afterwards, some tables of temperature—what is your opinion as to the time of year or temperature at which the sewage matter would come to be noxious or unpleasant, or injurious in any way?—At over 60°, say from 65° to 70°.

7415. Do you mean the temperature of the water, or of the air?—The temperature of the water. I have taken the temperature of the water for many years in England, and I know at what temperature it would become noxious, and I can compare the result of known temperatures with the recorded state of the Thames. I beg to hand in two tables of recorded temperatures.

*The same were handed in, and are as follows:—*

*Mr. B. Latham, M. Inst. C.E., F.G.S., F.M.S.*

23 Jan. 1883.

TABLE showing the NUMBER of DAYS in every MONTH when the TEMPERATURE of the THAMES WATER was above 60°, the NUMBER of DAYS it was above 65°, and the NUMBER of DAYS it was above 70°; and also the NUMBER of DAYS upon which no OBSERVATIONS were made.

| Year. | May. | | | | June. | | | | July. | | | | August. | | | | September. | | | | October. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Above 60°. | Above 65°. | Above 70°. | No Observation. | Above 60°. | Above 65°. | Above 70°. | No Observation. | Above 60°. | Above 65°. | Above 70°. | No Observation. | Above 60°. | Above 65°. | Above 70°. | No Observation. | Above 60°. | Above 65°. | Above 70°. | No Observation. | Above 60°. | Above 65°. | Above 70°. | No Observation. |
| 1844 | 5 | — | — | 18 | 23 | 9 | — | 2 | 30 | 16 | — | 1 | 27 | 1 | — | 1 | 22 | 1 | — | — | — | — | — | 1 |
| 1845 | — | — | — | — | 20 | 12 | — | — | 31 | 4 | — | — | 16 | — | — | 2 | 3 | — | — | — | — | — | — | — |
| 1846 | 12 | — | — | — | 28 | 27 | 23 | 2 | 17 | 17 | — | 14 | 31 | 31 | 10 | — | 22 | 19 | — | 8 | — | — | — | 31 |
| 1847 | 10 | 4 | — | — | 29 | 11 | 3 | 1 | 31 | 31 | 19 | — | 31 | 16 | 7 | — | 3 | — | — | — | — | — | — | — |
| 1848 | 20 | 8 | — | 4 | 30 | 5 | — | — | 31 | 24 | — | — | 31 | 3 | — | — | 9 | — | — | 21 | 3 | — | — | 4 |
| 1849 | 9 | 1 | — | — | 30 | 18 | — | — | 17 | 17 | 5 | 14 | 26 | 14 | — | 5 | 17 | 7 | — | — | — | — | — | — |
| 1850 | 3 | — | — | — | 30 | 18 | 3 | — | 31 | 21 | 1 | — | 31 | 19 | — | — | 8 | — | — | — | — | — | — | — |
| 1851 | 6 | — | — | — | 28 | 5 | — | 2 | 7 | 3 | — | 24 | 31 | 27 | — | — | 21 | — | — | — | — | — | — | — |
| 1852 | — | — | — | 21 | 15 | — | — | 11 | 17 | 15 | 12 | 14 | 31 | 30 | 4 | — | 20 | 11 | — | — | — | — | — | 13 |
| 1853 | 8 | — | — | — | 25 | 3 | — | — | 31 | 10 | — | — | 30 | 14 | — | 1 | 6 | — | — | — | — | — | — | — |
| 1854 | — | — | — | — | 13 | 3 | — | — | 31 | 14 | 4 | — | 31 | 18 | — | — | 29 | 14 | — | — | — | — | — | — |
| 1855 | — | — | — | 10 | 17 | 2 | — | 4 | 31 | 30 | — | — | 31 | 31 | — | — | 30 | 5 | — | — | 7 | — | — | — |
| 1856 | 5 | — | — | — | 27 | 9 | — | — | 31 | 20 | 1 | — | 31 | 23 | 16 | — | 20 | — | — | — | — | — | — | — |
| 1857 | — | — | — | — | 30 | 9 | 3 | — | 26 | 26 | 10 | 5 | 29 | 29 | 12 | 2 | — | — | — | — | — | — | — | — |
| 1858 | 5 | — | — | — | 30 | 27 | 11 | — | 31 | 21 | 1 | — | 28 | 28 | — | 3 | 30 | 1 | — | — | 4 | — | — | 2 |
| 1859 | 2 | — | — | 7 | 30 | 25 | — | — | 31 | 31 | 25 | — | 31 | 31 | 5 | — | 21 | 5 | — | — | 16 | — | — | 9 |
| 1860 | 6 | — | — | — | 7 | — | — | — | 24 | — | — | 7 | 31 | — | — | — | 11 | — | — | — | — | — | — | — |
| 1861 | 7 | — | — | 11 | 30 | 8 | — | — | 31 | 25 | — | — | 31 | 29 | — | — | 14 | 5 | — | 9 | 1 | — | — | — |
| 1862 | 7 | — | — | — | 28 | — | — | — | 25 | 5 | — | — | 31 | 9 | — | — | 27 | — | — | — | 10 | — | — | — |
| 1863 | — | — | — | — | 30 | 7 | — | — | 31 | 25 | 4 | — | 29 | 27 | — | 2 | 26 | 2 | — | — | — | — | — | — |
| 1864 | 14 | — | — | — | 28 | — | — | 1 | 8 | 8 | — | 23 | 31 | 13 | — | — | 29 | — | — | — | 1 | — | — | — |
| 1865 | 11 | 2 | — | — | 30 | 24 | — | — | 28 | 26 | — | 3 | 29 | 7 | — | 2 | 27 | 16 | — | 3 | 7 | — | — | 4 |
| 1866 | — | — | — | 1 | 27 | 7 | — | 1 | 30 | 20 | 1 | 1 | 31 | — | — | — | 9 | — | — | 1 | — | — | — | — |
| 1867 | 5 | — | — | — | 26 | — | — | 2 | 28 | 10 | — | 3 | 28 | 12 | — | 3 | 15 | 3 | — | 2 | — | — | — | 3 |
| 1868 | 16 | — | — | — | 30 | 15 | — | — | 30 | 30 | 6 | 1 | 31 | 23 | 2 | — | 18 | 2 | — | 1 | — | — | — | 4 |
| 1869 | — | — | — | 1 | 2 | — | — | 3 | 27 | 18 | — | 2 | 31 | 4 | — | — | 8 | — | — | 3 | — | — | — | — |
| 1870 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1871 | 5 | — | — | — | 17 | — | — | — | 31 | 20 | — | — | 29 | 28 | 12 | 2 | 23 | 13 | — | — | — | — | — | — |
| 1872 | 2 | — | — | — | 25 | 12 | — | — | 31 | 31 | 7 | — | 31 | 27 | 2 | — | 21 | 16 | — | — | — | — | — | — |
| 1873 | — | — | — | — | 21 | 5 | — | — | 31 | 25 | 1 | — | 31 | 26 | — | — | 9 | — | — | — | — | — | — | — |
| 1874 | 3 | — | — | — | 30 | 9 | — | — | 31 | 23 | 8 | — | 15 | 4 | — | 16 | 25 | — | — | — | 2 | — | — | — |
| 1875 | 17 | — | — | — | 29 | 1 | — | — | 31 | 8 | — | — | 31 | 28 | — | — | 30 | 17 | — | — | — | — | — | — |
| 1876 | — | — | — | — | 29 | 9 | — | — | 31 | 31 | 11 | — | 31 | 29 | 8 | — | 20 | — | — | — | 3 | — | — | — |
| 1877 | — | — | — | — | 25 | 19 | — | — | 31 | 25 | — | — | 31 | 30 | — | — | 17 | — | — | — | — | — | — | 4 |
| 1878 | 14 | — | — | — | 24 | 6 | 1 | — | 31 | 31 | 14 | — | 31 | 30 | — | — | 21 | — | — | 1 | 3 | — | — | — |
| 1879 | — | — | — | — | 23 | — | — | — | 31 | 1 | — | — | 31 | 11 | — | — | 17 | — | — | — | — | — | — | 6 |

## Temperatures of the River Thames.

| Year. | January. | | February. | | March. | | April. | | May. | | June. | | July. | | August. | | September. | | October. | | November. | | December. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. |
| 1844 | — | — | — | — | — | — | — | — | 62·5 | 52·0 | 67·8 | 54·0 | 69·5 | 61·0 | 66·0 | 58·2 | 66·5 | 55·0 | 56·0 | 47·0 | 51·0 | 41·0 | 42·0 | 31·0 |
| 1845 | 41·8 | 35·5 | 39·0 | 30·0 | 47·0 | 32·0 | 55·0 | 45·0 | 56·0 | 51·5 | 67·0 | 55·5 | 67·8 | 61·8 | 64·0 | 58·0 | 61·8 | 53·8 | 55·0 | 47·5 | 49·5 | 45·5 | 44·0 | 37·2 |
| 1846 | 50·5 | 36·5 | 51·0 | 37·0 | 52·0 | 43·8 | 54·0 | 45·8 | 64·8 | 51·5 | 77·0* | 63·0 | 69·5 | 65·0 | 71·5 | 63·8 | 67·5 | 59·5 | — | 47·0 | 48·0 | 42·0 | 44·5 | 31·8 |
| 1847 | 41·5 | 33·0 | 44·0 | 32·5 | 47·2 | 36·0 | 50·8 | 43·3 | 69·5 | 49·5 | 70·5 | 60·0 | 75·0 | 62·5 | 72·2 | 61·5 | 62·5 | 54·8 | 55·5 | 49·0 | 51·5 | 42·0 | 45·8 | 35·5 |
| 1848 | 40·0 | 31·5 | 46·0 | 33·0 | 45·8 | 42·5 | 53·0 | 48·8 | 67·5 | 50·0 | 66·0 | 61·0 | 68·5 | 61·5 | 66·0 | 59·8 | 63·5 | 55·8 | 61·0 | 46·0 | 48·0 | 38·8 | 48·0 | 31·8 |
| 1849 | 46·5 | 32·0 | 45·9 | 40·1 | 48·1 | 1·1 | 57·4 | 40·0 | 65·3 | 50·5 | 68·8 | 59·6 | 70·8 | 63·4 | 68·3 | 60·4 | 66·3 | 55·1 | 58·8 | 43·7 | 52·3 | 36·4 | 44·8 | 29·9 |
| 1850 | 39·0 | 29·4 | 45·6 | 36·4 | 45·8 | 35·7 | 52·8 | 38·7 | 62·6 | 47·0 | 70·6 | 60·0 | 70·1 | 60·0 | 68·1 | 58·5 | 61·4 | 54·7 | 57·6 | 43·0 | 50·1 | 39·5 | 43·1 | 33·5 |
| 1851 | 46·1 | 35·7 | 44·6 | 36·5 | 49·1 | 36·3 | 55·7 | 43·0 | 63·5 | 48·0 | 68·5 | 57·7 | 66·0 | 62·6 | 69·8 | 59·5 | 64·0 | 55·0 | 57·5 | 49·6 | 52·0 | 36·5 | 44·5 | 36·4 |
| 1852 | 45·2 | 36·8 | 47·8 | 37·2 | 45·8 | 37·4 | 52·5 | 44·5 | 56·0 | 49·5 | 65·0 | 55·0 | 73·4 | 62·0 | 72·0 | 61·5 | 67·8 | 54·5 | 56·5 | 43·7 | 53·5 | 40·6 | 48·5 | 40·2 |
| 1853 | 43·2 | 38·9 | 40·3 | 34·2 | 45·7 | 36·3 | 51·7 | 43·2 | 63·7 | 50·0 | 65·2 | 56·7 | 67·9 | 60·1 | 66·5 | — | 63·9 | — | 58·1 | 51·2 | 58·5 | 39·3 | 43·4 | 33·2 |
| 1854 | 45·8 | 32·1 | 46·5 | 37·5 | 49·6 | 40·7 | 57·6 | 46·5 | 59·8 | 48·5 | 65·8 | 61·3 | 71·5 | 60·7 | 69·0 | 60·3 | 67·7 | 55·7 | 60·0 | 47·9 | 50·5 | 40·3 | 43·5 | 40·3 |
| 1855 | 45·0 | 34·7 | 37·5 | 33·2 | — | — | — | 39·0 | 58·9 | 48·7 | 66·9 | 53·7 | 69·7 | 62·3 | 68·4 | 64·5 | 66·6 | 57·7 | 61·4 | 50·2 | 50·9 | 40·5 | 43·3 | 31·2 |
| 1856 | 45·5 | 35·6 | 48·5 | 36·1 | 45·5 | 40·3 | 54·9 | 43·7 | 61·9 | 46·9 | 69·4 | 53·9 | 70·5 | 61·7 | 73·0 | 61·2 | 64·1 | 54·5 | 58·4 | 48·7 | 51·5 | 40·3 | 49·5 | 36·9 |
| 1857 | 41·5 | 37·3 | — | — | — | — | — | — | 61·7 | — | 72·4 | 60·2 | 71·9 | 61·4 | 71·7 | 65·3 | — | — | — | — | 54·7 | 42·5 | 47·8 | 42·3 |
| 1858 | 44·8 | 35·9 | 42·3 | 36·0 | 47·7 | 34·1 | 58·7 | 42·5 | 61·5 | 51·2 | 72·4 | 60·2 | 70·4 | 60·5 | 69·5 | 61·7 | 65·2 | 59·2 | 60·7 | 54·2 | 48·8 | 37·6 | 43·5 | 40·5 |
| 1859 | 43·2 | 39·2 | 45·3 | 41·0 | 49·1 | 44·3 | 54·2 | 46·3 | 61·7 | 49·5 | 67·5 | 60·7 | 75·4 | 65·2 | 71·4 | 65·6 | 66·7 | 58·2 | 62·2 | 54·5 | 49·8 | 42·6 | 42·2 | 35·3 |
| 1860 | 48·0 | 39·8 | 40·5 | 30·8 | 48·0 | 38·8 | 48·5 | 45·0 | 62·0 | 47·2 | 62·5 | 56·0 | 64·5 | 61·0 | 62·5 | 59·5 | 61·5 | 54·5 | 55·5 | 49·0 | 52·0 | 41·0 | 45·0 | 33·0 |
| 1861 | 42·0 | 31·0 | 45·0 | 41·5 | 47·0 | 42·5 | 52·0 | 46·5 | 62·0 | 51·0 | 67·5 | 59·5 | 67·5 | 63·8 | 67·5 | 64·0 | 66·0 | 55·0 | 60·0 | 52·0 | 54·5 | 34·0 | 47·5 | 40·0 |
| 1862 | 44·1 | 36·4 | 50·6 | 36·4 | 51·6 | 37·4 | 58·6 | 43·4 | 61·6 | 54·4 | 63·6 | 57·4 | 66·6 | 54·4 | 67·1 | 61·4 | 64·1 | 57·4 | 60·6 | 47·9 | 50·6 | 38·4 | 48·1 | 38·4 |
| 1863 | 41·6 | 37·4 | 46·1 | 39·4 | 48·6 | 42·4 | 56·6 | 47·4 | 59·6 | 52·6 | 67·1 | 58·4 | 70·2 | 62·1 | 69·1 | 62·4 | 65·6 | 54·9 | 56·8 | 51 9 | 53·6 | 45·6 | 47·9 | 41·6 |
| 1864 | 45·6 | 31·4 | 42·6 | 33·9 | 46·3 | 36·6 | 59·1 | 42·3 | 63·8 | 52·9 | 63·6 | 58 4 | 67·6 | 60·3 | 68·1 | 58·9 | 63·8 | 57·6 | 60·6 | 48·4 | 46·1 | 41·2 | 44·9 | 35·0 |
| 1865 | 41·9 | 31·8 | 43·9 | 33·2 | 44·4 | 36·7 | 59·4 | 39·7 | 65·9 | 56·2 | 67·9 | 62·7 | 67·1 | 64·4 | 65·9 | 62·7 | 68·2 | 63·2 | 62·9 | 47·6 | 46·9 | 42·2 | 46·0 | 40·7 |
| 1866 | 47·0 | 34·7 | — | 35·7 | 49·8 | 35·7 | 55·8 | 46·7 | 58·0 | 48·7 | 68·3 | 57·7 | 70·3 | 62·7 | 64·8 | 58·2 | 63·3 | 53·7 | 59·3 | 47·7 | 53·8 | 38·2 | 48·0 | 37·7 |
| 1867 | 44·3 | 30·2 | 48·8 | 38·4 | 47·8 | 33·7 | 54·3 | 42·7 | 63·8 | 48·7 | 64·8 | 55·7 | 66·8 | 58·9 | 67·8 | 65·7 | 66·8 | 53·7 | 56·2 | 42·7 | 53·3 | 38·7 | 42·9 | 33·7 |
| 1868 | 43·4 | 33·4 | 44·9 | 38·4 | 49·5 | 43·4 | 53·4 | 45·4 | 63·4 | 51·7 | 67·4 | 58·7 | 72·2 | 64·4 | 71·0 | 59·4 | 65·4 | 57·4 | 57·9 | 44·4 | 49·4 | 40·4 | 47·9 | 40·4 |
| 1869 | 44·8 | 35·4 | 48·4 | 41·4 | 43·4 | 37·4 | 56·9 | 50·4 | 56·4 | 50·9 | 60·9 | 50·4 | 69·9 | 57·4 | 67·4 | 59·2 | 63·4 | 54·4 | 59·4 | 41·5 | 46·9 | 40·7 | 44·5 | 32·1 |
| 1870 | 43·4 | 32·4 | 42·4 | 30·8 | 45·4 | 36·4 | — | 39·4 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| 1871 | 40·8 | 30·6 | 46·9 | 33·1 | 49·8 | 39·4 | 55·1 | 42·2 | 61·9 | 48·0 | 63·3 | 52·8 | 68·6 | 59·0 | 71·8 | 61·3 | 66·6 | 52·3 | 56·4 | 48·0 | 51·6 | 36·8 | 42·4 | 32·2 |
| 1872 | 43·1 | 35·9 | 46·3 | 41·5 | 50·0 | 39·2 | 55·6 | 45·6 | 60·4 | 50·6 | 68·6 | 57·3 | 73·4 | 63·0 | 71·4 | 61·0 | 66·2 | 53·0 | 56·0 | 46·5 | 50·6 | 40·0 | 46·6 | 36·0 |
| 1873 | 47·6 | 33·6 | 40·9 | 32·8 | 49·0 | 38·7 | 54·1 | 44·0 | 58·4 | 47·0 | 66·2 | 55·2 | 70·4 | 62·2 | 64·6 | 62·0 | 65·6 | 55·3 | 59·0 | 44·0 | 47·8 | 40·8 | 46·4 | 39·0 |
| 1874 | 44·1 | 37·5 | 43·3 | 36·2 | 49·6 | 39·2 | 59·0 | 45·6 | 61·4 | 51·0 | 67·0 | 59·0 | 71·4 | 61·8 | 66·6 | 61·0 | 64·6 | 57·5 | 60·8 | 51·0 | 53·6 | 41·8 | 43·2 | 31·6 |
| 1875 | 46·4 | 31·6 | 43·4 | 35·4 | 46·5 | 37·1 | 54·3 | 45·1 | 55·3 | 52·3 | 65·1 | 56·8 | 65·7 | 60·1 | 69·3 | 62·3 | 66·3 | 59·1 | 59·5 | 44·3 | 49·8 | 36·5 | 44·9 | 32·8 |
| 1876 | 45·3 | 33·8 | 47·8 | 35·3 | 48·1 | 36·5 | 55·3 | 42·9 | 57·3 | 50·1 | 67·3 | 56·1 | 72·3 | 64·7 | 71·8 | 61·7 | 62·9 | 56·1 | 60·3 | 50·3 | 52·1 | 41·8 | 49·3 | 35·8 |
| 1877 | 48·3 | 38·9 | 49·1 | 39·7 | 48·3 | 38·7 | 52·5 | 45·3 | 57·3 | 46·3 | 69·3 | 55·3 | 67·3 | 61·5 | 69·3 | 63·1 | 64·3 | 53·8 | 56·1 | 48·5 | 52·5 | 40·8 | 44·3 | 38·1 |
| 1878 | 45·3 | 36·8 | 47·7 | 36·3 | 50·7 | 40·3 | 55·8 | 39·8 | 62·8 | 54·3 | 70·3 | 56·3 | 71·3 | 63·5 | 69·8 | 62·3 | 64·8 | 55·3 | 60·3 | 46·3 | 48·8 | 40·1 | 41·3 | 32·1 |
| 1879 | 43·3 | 31·3 | 45·3 | 32·9 | 47·3 | 36·3 | 51·5 | 41·3 | 58·5 | 47·5 | 63·8 | 55·3 | 65·3 | 56·3 | 66·3 | 58·3 | 62·5 | 55·3 | 57·8 | 48·3 | — | — | — | — |

* Maximum Thermometer reported to be out of order.

*Mr. B. Latham, M. Inst. C.E., F.G.S., F.M.S.*

23 Jan. 1883.

7416. Where were these tables taken from?—These tables were taken from the published records at Greenwich Observatory.

7417. I think they were taken under Mr. Glashier's superintendence?—The observations originally were.

7418. Where were they taken, at the "Dreadnought," or one of the ships lying in the Thames?—The temperature of the river Thames taken in "self-registering maximum and minimum thermometers which were observed daily at 9 a.m. The thermometers enclosed in a wooden trunk were attached to the side of the 'Dreadnought' hospital ship till April 13th 1870. Commencing with January 12th 1871, they were attached to the police ship 'Scorpion,' moored in Blackwall Reach. In May 1874 the wooden trunk was shifted from the 'Scorpion' to the 'Royalist,' moored in the same place. The wooden trunk, about 5 ft. in length, and enclosed at the bottom, was firmly fixed to the side of the ship; the bottom and the sides to the height of three feet were perforated with a great number of holes, so that the water could easily flow through; the thermometers were suspended within this trunk so as to be about two feet below the surface of the water and one foot from the bottom of the trunk. On October 18th 1879, the 'Royalist' received such damage, in consequence of another vessel having come into collision with her, that she was removed on October 19th to the West India Dock, when the observations were discontinued."

7419. (*Sir John Coode.*) Did she swing at her anchors, because it is rather important to know what was the aspect of the trunk in which the thermometers were placed?—It was immersed a foot below the surface, and it will be remembered that it was running water.

7420. (*Mr. Webster.*) The first table shows that in the month of May over a series of years from 1844 to 1879 there were very few days above 60°.?—Yes.

7421. In the month of June there were a very small number above 65°, and a certain number, but not a considerable number above 70°?—Yes.

7422. In the month of July there was still more, and in the month of August also?—Yes.

7423. I think on the other side you have put down the maxima and the minima?—Upon the other side I have taken the maxima and the minima in every month throughout the various years from 1844 to 1879.

7424. With regard to the rise of the tide, is there anywhere in your reports (I believe there is), the number of feet rise?—Yes, they are given on page 39.

7425. I should like to draw attention to some matters in your report which may perhaps give rise to questions; do you say this at page 41, "The observations on the range of the tide show that low water at Southend on an average of all the tides between September and November 1882 is 1·87 feet higher than at Deptford"?—That is so.

7426. "On the 27th September 1882 low water at Deptford was 2·5 feet lower than at Southend"?—Yes; that is so.

7427. "Low water at Gravesend on the average was 1·06 feet lower than at Southend and low water at Erith 1·52 feet lower than at Southend. High water at Southend on an average of all the tides from September to November 1882 was 2·06 feet lower than high water at Deptford;" that means measured from a datum line?—Yes.

7428. From a fixed datum line not relatively to the high water itself but from a fixed datum, it is lower or higher, as the case may be?—Yes.

7429. (*Sir John Coode.*) Taking it with regard to the mean sea level which is the ordnance datum?—Precisely.

7430. I believe you wish to put in another table of temperatures?—I wish to put in another table of temperatures which gives the average taken out by Sir George Airy.

*The same was handed in, and is as follows:—*

MONTHLY MEANS, through a RANGE of THIRTY-FIVE YEARS, of the PRINCIPAL ELEMENTS of the TEMPERATURE of the WATER of the THAMES. By Sir George Biddell Airy, K.C.B., F.R.S.

| Month. | Temperature of the Water of the Thames. | Atmospheric Temperature at the Royal Observatory. | Excess of Temperature of the Thames above Atmospheric Temperature. | Diurnal Range of Temperature of the Thames. | Diurnal Range of Atmospheric Temperature. |
|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° |
| January | 39·4 | 38·9 | +0·5 | 1·9 | 9·6 |
| February | 40·7 | 40·4 | +0·4 | 2·0 | 11·5 |
| March | 43·6 | 42·8 | +0·8 | 2·0 | 15·0 |
| April | 50·0 | 48·7 | +1·3 | 2·3 | 18·5 |
| May | 56·3 | 54·4 | +1·9 | 2·4 | 19·9 |
| June | 62·6 | 60·6 | +2·0 | 2·2 | 20·5 |
| July | 65·7 | 63·9 | +1·8 | 2·1 | 21·2 |
| August | 64·4 | 62·6 | +1·8 | 2·0 | 19·6 |
| September | 59·9 | 57·9 | +2·0 | 1·9 | 18·1 |
| October | 52·9 | 50·7 | +2·2 | 2·0 | 14·3 |
| November | 44·3 | 42·3 | +2·1 | 2·1 | 11·3 |
| December | 40·4 | 39·8 | +0·6 | 2·1 | 9·1 |

7431. (*Chairman.*) Why do you call particular attention to the fact that the low tide is higher at Southend than it is at Deptford?—It is a curious fact, and it shows that the river in flowing down does not obey the ordinary law of water, moving down hill because it moves up hill; it is moving by tidal impulse still, and not by the ordinary law of flowing.

(*Chairman.*) The water comes rushing down and finds itself in a narrower channel, and so goes on rising as if it struck a rock, is that how you would account for it.

(*Mr. Webster.*) But the highest point is lower down the river when it is running out. If your Lordship would kindly look at page 45 of Mr. Latham's

report, he quotes from a report in 1858 of Messrs. Bidder, Hawksley, and Bazalgette, three names well known to us, mentioning, that the diagram of the vertical range of the tides referred to was evidently in error, as low water in the lower part of the river was shown to be higher than in the upper part of the river. The recent observations, as well as others, show that the error was not made by the Government referees (the Government referees had so reported it), and that high water at, say London Bridge, is higher than high water at Sheerness, so low water in the river at London Bridge is absolutely lower than low water at Sheerness.

7432. (*To the witness.*) What is more important is this, do you draw any inference with regard to the question before us from the fact that there is a higher low tide in the lower river at Southend than there is at Deptford?—It has no very important bearing upon the question.

7433. (*Chairman.*) If it is of any importance it is worth explaining?—You must not treat the Thames as an ordinary river running down hill, but it must be dealt with as a tidal river running with a tidal impulse. In a recent inquiry the Thames has been treated altogether as an ordinary river running down hill.

(*Chairman.*) All rivers do not run down hill; the river Mississippi runs up hill. Its mouth is at a greater distance from the centre of the earth than its source is. I mention that simply as a remarkable fact.

7434. (*Mr. Webster to the witness.*) You have mentioned incidentally that the sewage is assumed to contain 10 parts in 100,000 of chlorine; what from your experiments do you find to be the amount of solid matter in sewage as discharged at Barking?—With regard to the amount of solid matter in the sewage which is discharged at Barking, I have taken the results which were published by the Metropolitan Board of Works as to the A.B.C. experiments, and I find that the quantity of solid matter as shown by those experiments made in the autumn of 1872, in which 11,672,737 gallons of sewage were treated, showed as the amount of solid matter a little over 57 grains in a gallon.

7435. (*Sir John Coode.*) Does that mean 57 grains which could be filtered off—which were in suspension?—Those experiments show clearly that there were 57 grains in a gallon in suspension in this quantity of water which was treated.

7436. (*Chairman.*) Do you know who actually made these experiments?—They were made by the late Mr. Keates.

7437. (*Sir P. Benson Maxwell.*) What are you reading from?—I am reading from my notes. Mr. Keates was the chemist to the Board. In 1872 the Metropolitan Board of Works undertook to conduct a careful series of observations under their own supervision as to the effect of the A.B.C. process in purifying the sewage of the Metropolis. The native Guano Company erected works at Crossness, and every day the quantity of sewage used at the works was tabulated and the quantity of manure produced, and the various materials were analysed, and from these reports I arrive at the conclusion that the quantity of solid matter in suspension in the sewage was 57·41 grains per gallon.

7438. (*Mr. Webster.*) Would you answer a question which was put by a member of the Commission just now. Is that solid matter which could be filtered out?—That is the solid matter in suspension, not the solid matter in solution at all.

7438*a*. (*Chairman.*) Does that mean grains in weight?—Grains in weight, a gallon of water being 70,000 grains.

7439. (*Mr. Webster.*) A gallon of sewage contains 57 grains of solid matter, not in solution but in suspension, which is really about three quarters of a grain to 1,000?—Yes.

7440. I wish to ask you what is your view of the effect upon the sewage of this washing up and down, or this oscillation backwards and forwards in the bed of the river, between above and below Barking?—As these reservoirs have been constructed at such a level that they cannot be emptied ordinarily until three hours after high water, the effect of the first of the sewage would be to flow down 12 miles, but the last would only go six miles—the next tide would bring the last outflow six miles above the outfall, the last being discharged three hours after the first.

7441. (*Chairman.*) The outlet is at half ebb?—The level of the floor of the reservoir is 2·75 above ordnance datum, and as at that level the tide in the river ordinarily is not low enough to enable it to empty until three hours after high water, it cannot empty until three hours after high water. If the water were low enough in the river to allow it, the outlets would allow it to go out quicker; it does not fall sufficiently quick ordinarily to let it get out of the reservoir until three hours after high water.

7442. During the first three hours of the ebb how far would it get out?—12·6 miles is the average range of all our experiments; the Metropolitan Board of Works have always taken it as 12 miles.

7443. The water that is flowing out during the half ebb flows out for three hours?—It does.

7444. At what rate per hour does the ebb go?—It would go two miles an hour; there would be a section of six miles of river occupied by sewage, and the next section would have no sewage in it. That which was last discharged would go down six miles, but when the tide turned that would flow back for a distance of 12 miles.

7445. (*Chairman.*) As I understand, you do not begin to discharge until half ebb?—No; they begin on the top of the flood and discharge to half ebb.

7446. Do they not discharge the whole of the ebb?—I have seen the sewage running out of the northern outfall, but in principle they do not.

7447. (*Mr. Webster.*) I was not dealing with the question of time or flow. I wanted first to know what, in your judgment, was the general effect of the sewage water being oscillated backwards and forwards, and being at the same time also mixed; has that any effect upon the deposit?—Of course all the parts which are heavier than water, being run backwards and forwards, and also coming to rest at the end of each tide, are precipitated to the bottom of the river. And this constant oscillation in hot weather is certainly most deleterious; it is not so bad at other times as in hot weather, and that is the reason I was so careful to get out the temperature tables.

7448. Of course the matter which does not deposit would be more or less impure as long as the mixing went on?—Yes.

7449. Would the fact of the sewage staying in the river in hot weather, assuming it to be not mixed, tend to make it more noxious?—Yes, because I take it that when the weather is hot, decomposition of the matter which has been deposited and decomposition of the matter held in suspension takes place, and then the tidal water is filled with the gases of decomposition, and is not capable of oxydising the impurities of the sewage.

7450. I understand you to say that the floor of the reservoir is 2·75 feet above ordnance datum?—Yes.

7451. During what hours can they discharge from the top of the flood?—Occasionally they can discharge from the top of the flood until three hours afterwards; there are times at which they can discharge to 2½, and there are cases in which the tide has dropped rapidly, and they can only discharge to two hours.

7452. Do you know whether they are able to limit the discharge to those periods of time; do you know whether they have occasionally to discharge upon the flood tide, for instance?—I know the reservoir will only hold the quantity of sewage which the sewers are capable of bringing down in two or three hours, and then when those sewers are running full for a longer period, sewage must be overflowing into the river.

7453. There is a pumping station at Grosvenor Road, or Victoria Bridge, as it is called?—There is.

*Mr. B. Latham, M. Inst. C.E., F.G.S., F.M.S.*

23 Jan. 1883.

7454. For what purpose is that?—That is for the purpose of dealing with the sewage of what is termed the Western District.

7455. To pump it so that it may go where?—So that it may go into the low level sewer, where it is taken by gravitation to Abbey Mills, and then it is pumped into the sewer going to Barking.

7456. As a matter of fact do you know whether at times that sewage has to be discharged direct into the Thames?—I know it must be so from this fact. At the time when the Metropolitan Board of Works made their outfall sewer, they proposed to deal with this district separately by deodorising works at the Kensington Canal, and when the northern outfall was more than half completed they proposed to take the western district sewage to Barking, and the consequence is that whenever the amount which the sewers are calculated to take is running in the sewers the whole of the sewage of the western district must be discharged at some other point.

7457. (*Mr. Bidder.*) Do you say that from observation, from having seen it run in?—I have seen it running in day after day at Grosvenor Road.

7458. (*Chairman.*) The sewers are calculated to carry a certain amount of water, and when they will not carry that particular amount of water there is an overflow into the Thames?—That is so.

7459. Has that anything to do with the sewer in question?

(*Mr. Webster.*) It will have.

(*Chairman.*) His observation may go to show that the sewer is not big enough for its purpose, that is all.

(*Mr. Webster.*) It will go to show that the sewers were not constructed for the burden they now have to bear, and that, as a matter of fact, the sewage has to be discharged direct.

(*Chairman.*) I think that is an important thing to bear in mind.

(*Sir John Coode.*) Is it not the fact that Sir Joseph Bazalgette admitted that to us in his first evidence, and said that the Metropolitan Board of Works were proposing a remedy, but that they were prevented from applying that remedy until this inquiry came to a close.

(*Mr. Webster.*) That was so. All I am directing my evidence to is to show what is the effect of the way in which the sewers are now working, and the effect of their incapacity to do their work.

(*Mr. Bidder.*) I admit that there are occasions, when there is a heavy rainfall, when we cannot restrain ourselves until high water. Again I say that the difficulty the Board of Works have to grapple with is, that they are discharging sewage in Barking under these difficulties, and what I am pointing out is only that the Commissioners may see that there is a growing need.

(*Chairman.*) Your witness went to show that the western sewage went into the river; that is material as showing that they very likely calculated their areas upon an erroneous footing, because they are putting in sewage at a higher point than was intended.

(*Witness.*) What the Board proposed was to increase the capacity of the reservoirs 50 per cent., that is quite clear from their last published report to Parliament.

(*Mr. Webster.*) You are not now proposing the method in which you would remedy this, but I would ask you this, would any further increase of holding space down at Barking remedy, in your opinion, the evils that exist in turning out the sewage at Barking?—It would not.

(*Mr. Webster.*) There are other ways of dealing with it, for instance, such as taking out the solids, which I do not propose to go into at present.

Adjourned to to-morrow at half-past twelve.

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# SIXTEENTH DAY.

## Wednesday, 24th January 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR P. BENSON MAXWELL.
SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANCOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.

W. POLE, Esq., F.R.S., *Secretary.*

Mr. BALDWIN LATHAM, Mem. Inst. C.E., further examined.

*Mr. B. Latham, M. Inst. C.E.*

24 Jan. 1883.

(*Mr. Lumley Smith.*) I shall be glad if your Lordship would allow me, before we pass to a fresh head, to ask one or two questions with regard to certain matters which passed yesterday, to which we wish to add one or two observations.

7460. (*To the witness.*) I believe, returning for a moment to the float experiments, that on some occasions deep floats were used, and on others surface floats?—That is so.

7461. I believe you have one general observation, it is not a matter of detail, but you have one general observation to make with regard to the comparative velocity of progression of the deep float and the surface float, have you not?—I have.

7462. What is the conclusion you come to from the experiments with regard to the deep and the surface floats?—It will be found at page 37 of my Report. I found that, in ascending the river, on the average, the surface floats moved with a less velocity than the deep floats, but on descending the river the surface floats moved with the greater velocity; we give the figures in the Report.

7463. Have you any theory with regard to the explanation of that fact, or is it merely a matter of observation which you think ought to be recorded?—I have simply recorded the fact. I explained yesterday the probable cause of it.

(*Chairman.*) Need we trouble ourselves with the theory of it; will it assist us in our investigation?

(*Mr. Lumley Smith.*) Only to this extent, that my learned friend having suggested yesterday that there might be a discrepancy with regard to observations made at the same time, it was possible that the difference in the nature of the floats might account for it.

7464. (*To the witness.*) Now, passing on, I think you have given, have you not, at page 38 of your Report, which has been handed in, a table of the difference between ebb and flow at certain places mentioned in the book?—I have. That I took from the diagrams of the vertical range of the tides.

7465. The times of ebb and flow vary at different points on the river?—The times of flood and ebb vary, the flood being shorter, and the ebb being longer throughout the river; but all these times vary from one point to the other; they are nearer together in the lower part of the river, and more unequal in the upper part.

7466. At Teddington there are only two hours of flood and ten hours of ebb; at Southend, on the other hand, there are 6h. 3m. of flood and 6h. 22m. of ebb?—That is so.

7467. Does that vary with regard to spring tides and neap tides, or is it the average of both?—This is the average of a number of months' experiments.

7468. You wish to draw attention also to the fact, which you will find in your book on page 39, that the tides are actually rising; that is the conclusion you have come to?—There is an increased range of tides in the Thames to what there was formerly.

7469. Can you give any particular place at which the comparison can be taken?—I have shown it at page 39.

7470. I see that Mr. Redman's paper takes the range of tides in the Pool. What would be the nearest corresponding point that you have taken?—Deptford will be the nearest of our tidal stations to the Pool.

7471. Having taken Deptford, I wish to draw your attention to the fact, if you look at Mr. Redman's table, that although in 1800 it was 18 feet in the Pool, and rose gradually until 1874 when it was 22 feet, yet in 1882 Deptford does not seem to have been higher?—Those are the extremes.

7472. Mr. Redman's are extremes?—Yes; and if you compare my centre table at page 40 with that, you will find it shows that it has rather gone on in an increasing range from 1874; that the range at Deptford is 23·8 feet upon the 28th of September tide.

7473. This is a matter which I presume is independent of the embankment, or any local matter of that kind; have you any theory upon that matter?—I think it is due in a great measure to the gradual deepening of the river from dredging operations.

7474. That causes the tidal wave at ebb and flow to become greater?—It tends to accelerate its flow, and to make it become greater.

7475. From these observations of the tide, I think you deduce, do you not, the mean tide level?—Yes; from all the observations of three months we have deduced the mean tide level in the river from Southend to Deptford, and then we give the mean tide level at Teddington, taking the number of tides when there is an average quantity of water coming down the river.

7476. The mean tide level at Deptford is how much above ordnance datum?—It is 1·98.

7477. At Teddington Lock it is 11, and at Erith Pier 1·96?—And at Gravesend Pier it is 1·94, and at Southend Pier 1·89.

7478. Teddington had to a certain extent to be calculated?—Teddington had to be dealt with separately, as the volume of river water materially affects the question.

7479. With regard to the outfalls, which of those would most nearly correspond with the mean tide at the outfalls?—The mean would be between Erith and Deptford.

7480. Between 1·96 and 1·98?—Yes.

7481. The mean tide is half way between high water and low water?—The mean tide is half way between high and low water.

7482. Would that vary with different tides, or is that fairly constant?—It varies somewhat between neaps and springs; but this is the average, taking three months' observations. I ought to mention that I find that that level does not agree with the level given by the Metropolitan Board of Works.

7483. You might tell us, perhaps, what the Metropolitan Board put their level at?—In the Report of Messrs. Bidder, Hawksby, and Bazalgette, of the 6th of April 1858, there is a diagram at the end which shows the mean tide level to be 1·5 half tide. It also shows the mean high water to be 11 feet above ordnance datum, and the mean low water to be 7 feet below. Now the mean of those figures shows that the 1·5 is incorrect, and that it ought to be 2 feet exactly.

7484. From the figures they give, the 11 and the 7, it will come to 2, which you find to be more correct?—Yes.

*The Chairman* intimated that these minutiæ were not material to the issue before the Commission.

7485. (*Mr. Lumley Smith.*) Now one general observation with regard to the effect of the tide. I believe the total distance from the Nore up to the outfall is 36 miles, is it not?—It is 36¼ miles.

7486. You ascertained by your float experiments what the ordinary range of a float was on a tide?—Yes.

7487. What may you take that roughly at?—Upon a flood tide the average of all results is 12·6 miles, on the ebb 12·64 miles.

7488. (*Chairman.*) Do you mean the distance it went?—The average of all the ranges up and down. Of all the ranges up it would be 12 miles and $\frac{6}{10}$ths, the average of all the flows down is 12$\frac{64}{100}$ths.

(*Mr. Lumley Smith.*) Taking one particular tide.

7489. (*Chairman.*) There is only a difference of $\frac{4}{100}$ths?—Yes.

(*Chairman.*) That amounts to a furlong practically.

7490. (*Mr. Lumley Smith.*) The distance from the outfall to the Nore is practically three times the range of the tide?—Yes, in round numbers.

7491. Then, assuming the sewage to be carried along in the Thames as a float would be, sewage poured out upon the top of the tide at Barking would get down a distance of 12 miles?—12·6 miles upon the average.

7492. Assuming the sea water to enter the Nore at the same rate at which the float was found to travel up upon the same tide, the water would come from the sea a distance of 12 miles?—12·6 miles.

7493. Then there would be an intermediate 12 miles into which in the course of a single tide no fresh water would come from one end and no sea water would come from the other?—That is so.

7494. What is the effect of the tidal wave, in your judgment, with regard to water being forced up the river?—The tidal wave acts by impulse upon the body of the water which is in the mouth of the river and propels it up the river, so that if there were no mixing action going on, the water which is in the lower part of the river at low water would be identical with the water at the end of the range of the tide, 12·6 miles higher up, at high water.

7495. May I take it that the mixing action is due to currents and all kinds of things?—The mixing action is principally due to currents; it is due to the fact that, while the ebb is still running down, the flood is running up the sides of the river.

7496. (*Sir John Coode.*) Have you made any deep-water observations in order to ascertain whether the early flood makes up at the bottom much before it appears upon the surface?—We intended to do so, but the weather prevented us making the experiment.

7497. Then you have no fact to go upon with regard to that?—No; we only made the chlorine experiments. We intended to have done so by means of current meters.

7498. (*Mr. Lumley Smith.*) Apart from mixing, you think the mass of 12 miles of river would be simply forced up and then returned again?—There would be a body of water constantly oscillating backwards and forwards in the Thames in one tide, no change taking place.

7499. (*Chairman.*) One twenty-fifth of a mile in 12 miles would make it about one per 300; would not the result of that be that it would take 300 tides before anything starting would have got to the end of the first division of 12 miles?—That would be correct, assuming that the float observations represented the true flow of the river, but they represent really an exaggerated flow.

*Mr. B. Latham, M. Inst. C.E.*

24 Jan. 1883.

7500. There are two tides in the day; so it would take about two years according to that, supposing there were no mixing, before any water or log, or float, or anything else put in at Crossness would be in the sea finally; that is so, is it not?—Yes; assuming there is no mixing, and assuming there is no displacement, that would be true.

(*Mr. Lumley Smith.*) Your Lordship gets the $\frac{1}{25}$th by subtracting the 12·64 from the 12·60.

(*Chairman.*) Yes; but bear in mind that the more mixing you make the more you extenuate the case of the Board. On the other hand, the more you facilitate its getting up towards the upper part of the river the more you extenuate the mixing, I suppose.

(*Witness.*) The mixing acts in two ways; if there were no mixing action we should not have the sea water up at Chiswick.

7500*a*. (*Mr. Lumley Smith.*) And you not only get the mixing action, but you get a current down the river which in flood times is very important?—If there were no mixing action going on, still the fresh water coming in would drive out by degrees the volume of water in the river.

7501. Apart from that, do you find from your investigation whether the extent to which the salt water gets up the river varies at different times of the year?—Yes; it is a well accepted maxim that as the amount of upland water decreases, so the salt water line advances up the river.

7502. Then in a wet season you find the salt water does not get so far up as in a dry season?—In a wet season it is shown (upon the 30th of November in one of the tables we have put in) that salt water does not get up anything like the distance it does at other times, because you will see at Deptford upon that day there is no sea water at all.

7503. Which table are you referring to?—The third table at low water of the 30th of November, but if you refer to the same period at low water upon the 14th of September you find that there is a measurable quantity of sea water in the river at that point.

7504. Then generally we may take it, it seems common sense almost, that in a wet season the salt water does not find its way so far up as in a dry season. Now, with regard to the rate at which the tidal wave advances, is there any ratio which that bears to the current?—The tidal wave advances according to a law which was discovered by a committee of the British Association many years ago, and that is, that in a rectangular channel it is equal to the square root of half the depth. That is, that the wave would move with a velocity equal to that which a solid body would acquire in falling a distance equal to half the depth of the channel.

7505. It varies with the channel; but is there any rough ratio that you can tell us?—In the Thames we find, taking the area from Southend upwards, that the velocity of travel of the tidal wave is fifteen times as great as that of the ordinary flow of the tidal current.

7506. The average of the flow of the upland water has been taken from the table, has it not?—Yes. I have given you a calculation as to the average and the actual result. Upon the 22nd of September, when we get the tidal observations, they nearly correspond with the actual flow of the Thames.

7507. Comparing the rest of the year with the average, which is longest; the time when the upland water exceeds the average, or the time when the upland water is below the average?—The longest period is when the tendency is for the upland water to diminish in flow. Floods rise very rapidly, but the subsidence of the water is very slow afterwards, so that the period when the upland water is diminishing is longer than that in which it is increasing.

7508. That does not quite answer my question as to during what portion of the year the river is above its average and when it is below?—Of course there are exceptions, but, as a rule, in the autumn and spring it would be above; but there are well-known instances of summer floods in the Thames.

7509. The time when the float observations were taken was a time when there was a considerable flood coming in, was there not?—Principally; there has not been a dry period this year. I, myself, have been carrying on gaugings, for a particular purpose, for a number of years past, and I know that during the whole of the past year we have had an abnormally large quantity of water.

7510. I believe that yesterday, with regard to the chlorine test, you said you had had some figures furnished you by Professor Way?—Yes; and checked by Dr. Tidy.

7511. The table of chlorine observations supplied by Professor Way will be found at page 4 of the print which I am handing in. These were the figures to which you alluded yesterday as having been supplied to you?—Those are the results supplied to me by Professor Way and Dr. Tidy as to the amount of chlorine in different points which were taken out as the bases of the calculation as to the mixing action. (*The following table was handed in.*)

(*From the Analyses of Prof. J. T. Way.*)

| Locality. | Chlorine in 100,000 Parts of Water. 14th September 1882. | | Chlorine in 100,000 Parts of Water. 22nd September 1882. | | Chlorine in 100,000 Parts of Water. 30th November 1882. | |
|---|---|---|---|---|---|---|
| | High Water. | Low Water. | High Water. | Low Water. | High Water. | Low Water. |
| Teddington | 1·70 | 1·70 | 1·70 | 1·73 | 1·70 | 1·70 |
| Chiswick | 4·70 | 1.90 | 1·92 | 1·85 | 1·95 | 1·75 |
| St. Paul's Pier | 210·70 | 4·10 | 89·00 | 2·45 | 2·80 | 1·90 |
| Deptford | 438·00 | 49·00 | 311·00 | 28·80 | 20·00 | 1·85 |
| North Woolwich | 671·00 | 180·00 | 581·00 | 162·00 | 118·25 | 2·10 |
| Barking | 745·00 | 319·00 | 638·00 | 280·00 | 152·25 | 5·00 |
| Crossness | 918·00 | 470·00 | 754·00 | 440·00 | 276·00 | 18·75 |
| Erith | 1,031·00 | 530·00 | 836·00 | 555·00 | 314·25 | 83·75 |
| Gravesend | 1,502,00 | 1,058·00 | 1,352·00 | 1,062·00 | None taken. | None taken. |
| Southend | 1,931·00 | 1,765·00 | 1,891·00 | 1,816·00 | 1,785·00 | 1,522·5 |
| Margate | — | — | — | — | 1,770·00 | 1,735·5 |

7512. I take it as the explanation of these tests that, on three distinct days, upon the 14th of September, the 22nd of September, and the 30th of November, samples of water were taken at the places mentioned in that list?—They were.

7513. Namely, at Teddington, Chiswick, St. Paul's Pier, Deptford, North Woolwich, Barking, Crossness, Erith, Gravesend, Southend, and Margate?—They were, at high and low water.

7514. And those samples were submitted to Professor Way for his analysis?—Yes.

7515. Of course, with regard to his analysis, he would be the proper person to explain it, and not you?—He can better explain it.

7516. Are you able to explain, or shall I keep that for him, the way in which, from knowing the amount of chlorine in a sample of water at a particular place, you can form any conclusion as to the amount of sea water present as compared with the river water and sewage?—That has been entirely done by myself and others who have assisted me in the matter.

7517. Will you explain that to the Commission. May I take it, first of all, to clear the ground for the moment, that if the amount of chlorine in a particular fluid is known, and also if the amount of chlorine in another fluid is known, you can tell the amount of chlorine there ought to be in the mixture?—Certainly.

7518. Take it inversely, that if you know the amount of chlorine in one of the fluids, and the amount of chlorine in another, if you put your dipper into a pailful of the mixture, and find out how much chlorine there is in it you can tell the relative proportions of the mixture?—Yes.

7519. Here we have to deal with three fluids?—Yes.

7520. (*Chairman.*) If there is one fluid in which there are 20 grains of chlorine, and one in which there are 10, and you mix them in equal proportions you will find 30 grains in the mixture, and 15 if you take an equal volume of each ?—I have taken two cases, to simplify the matter, to show it synthetically; first, by building up a composition of a certain quality, that is if we take one volume of sea water, which we know contains 1,961 parts of chlorine in 100,000 parts, and if we take nine volumes of river water, each of which contain 1·7 parts, those nine volumes will equal 15·3, which, added to the 1,961, give 1,976·3; that is the amount of chlorine in 10 volumes, the one volume of sea water and the nine of fresh water. If we divide that by 10 it shows at once that the volume of chlorine in one volume of mixed water is a tenth part of that, or 197·63; that is showing what the composition of the fluid is synthetically. Now the chemist supplies us with an analysis of the mixed water.

7521. (*Chairman.*) You know the volume of the water you have put in ?—We have given you that, we have built that up.

7522. And in one volume of the mixture you ought to find 197·63 ?—We do. Then the chemist gives us one volume containing 197·63, and we have to find out in what ratio that is mixed. In order to do that you will observe I adopt the following formula. Let A equal the chlorine in sea water, which is 1,961 in the 100,000; let B equal the chlorine in the river water, which is 1·7 in 100,000; let C equal the chlorine in the mixed water, which is the amount the chemist gives us. The other two factors we also know from the composition of this water, which in this instance is 197·63 in 100,000 parts. To find out what quantity of river water there is mixed in the volume of sea water, if we take A minus C, and divide it by C minus B, we get the exact result, that there are nine volumes, as shown by these figures, we have built up before, that corresponds with the nine volumes we originally added to the mixture, proving that both synthetically and analytically it is correct. That is taking a very simple compound, but where we have three separate fluids mixing, it can be dealt with in exactly the same way. In this case I have built up a compound consisting of one volume of sea water, which contains 1,961 parts of chlorine, one volume of sewage, which contains 10 parts in 100,000, and I have taken 10 volumes of river water, each of which contains 1·7, or the 10 contain 17. If we add them up together it gives us 1,988 parts of chlorine in 12 volumes; if we divide that by 12 we get 165·66 parts of chlorine in one volume of the mixture. We know there that we have one volume of sewage containing 10, and we have 10 volumes of river water containing 17. If we divide the 27 by the 11 it shows us that in mixed river and sewage we have 2·45, that is the amount of chlorine in one volume of mixed sewage and river water. Now if we take the formula which we used in the first example and instead of calling B the amount of chlorine in the mixed river and sewage water we call it the amount of chlorine in the mixed water, and repeat the same operation, you will find from the figures that we have a mixture of 11 volumes, that is 11 volumes of mixed sewage and river water combined with one of sea water; so that the chemist supplying us with the figures, 165·66, we know for certain that that quantity of chlorine, were we dealing with fluids of known specific quality, could only be combined in those proportions to produce this result.

7523. (*Chairman.*) The object in these calculations is to find the proportion of chlorine attributable to sea water, and thereby to find out what proportion of sea water is attributable to the mixture ?—The object is by means of the chlorine to find out the proportion of sea water and river water and sewage in every part of the channel.

7524. (*Sir John Coode.*) And inasmuch as the sea water in the upper part of the river must have passed the outfall, that sea water must contain a portion of sewage ?

(*Witness.*) That is so.

7525. (*Chairman.*) Your object is to show that sewage is flowing up the river, and that is done by showing that the sea water gets up, and it cannot get up without its companion sewage; and in order to show that the sea water gets up, you find the quantity of chlorine in the water and you find that there is more than is attributable to the land water ?—Yes. I have worked here at great length a more elaborate mode showing how this formula is deduced; I beg to hand that in as giving examples (*handing in the same. See Appendix* U.).

7526. (*Mr. Lumley Smith.*) May I take it generally, that the object of the chlorine experiments is not to distinguish between the amount of river water and the amount of sewage, but to distinguish between what is sea water and what is not sea water ?—It is. You see the ultimate effect of it is this; if we show that there is only a certain portion in the whole river which is occupied by this mixture of river water and sewage (that is the channel which has every day to be displaced by the amount of upland water coming down), instead of having to displace the whole volume of the river, it has only to displace this smaller quantity, and, consequently, it goes out so much the faster, that is the measure of the mixing action.

7527. I suppose the importance of these observations increases down the river; it is useless taking them up above the bridge ?—Of course, they are much more important down the river, and the tables show to an enormous extent that the lower down the river you go, the greater the effect of the mixing action, because if the mixing action did not take place there would be the same amount of river and sea water all the way down.

7528. (*Dr. De Chaumont.*) In making these calculations, do you assume that the proportion of sewage and river water is the same at all points ?—We took the actual volume that we knew came down the river upon the same day; we took a standard of sewage by taking five cubic feet per head of the population, because you may take it that if there was anything that would increase the amount of sewage there would still be the same amount of chlorine going in, although in a larger volume. The population contributes the same proportion of sewage every day, although if it rained, it would go into a larger quantity of water.

7529. (*Mr. Lumley Smith.*) You know the fresh water coming over Teddington Weir ?—I know the quantity of fresh water coming over Teddington Weir on each of those days, and all through the district.

7530. And you know the amount of fresh water that comes in every day ?—We do, at every point of the river.

7531. Do you also know the amount of the sewage that goes into the river every day ?—We do, in that way, the standard sewage.

7532. You assume the mixture of river water and sewage to be of the same proportion as the daily flow of the water and sewage ?—That is so.

7533. As you know the amount of chlorine in each, it is easy to see what is the amount of chlorine in those two mixed ?—That is so.

7534. Those calculations are made upon the assumption that the sewage and fresh water are mixed in those ordinary proportions ?—Yes.

7535. In your judgment, is it fair to assume that they are mixed in those ordinary proportions ?—It is not only fair, but it is absolutely correct, because if there happens to be a larger amount of river water coming down it is measured in river water, whilst there is the same measure of chlorine coming from the population.

7536. You first of all mix the sewage and fresh water so as to make one fluid ?—Yes, to make one fluid.

7537. Then that mingles with the sea ?—That mingles with the sea; and I do it for this reason, that there may be changes going on in the sewage itself, but there can be no changes going on in the amount of chlorine in the sewage which may be taken as permanent; therefore, we take the amount of chlorine as indestructible.

*Mr. B. Latham, M. Inst. C.E.*

24 Jan. 1883.

7538. Then that reduces it to the two fluids mixing?—That is so.

7539. You assume the proportions of the two so as to reduce it to one fluid, and then you consider the sea water. As you know the amount of chlorine in each, it becomes very easy to gather from each sample how much is river water, how much is sewage, and how much sea water?—Certainly.

7540. (*Sir John Coode.*) You have ascertained the amount of fresh water coming over Teddington Weir every day during these observations?—Not only at Teddington Weir, but of all the tributaries down the river.

7541. Have you had gauges at the different places?—In 50 different places.

7542. So you have ascertained the quantity of water every day coming into the river?—Yes, with the exception of the 284 square miles which I stated were $\frac{1}{15}$th part of the whole drainage area of the Thames.

7543. (*Mr. Lumley Smith.*) Now the amount of chlorine, I think you told us yesterday, in the sea water is very large comparatively, is it not? I think you gave us the figure of 1,961 parts in 100,000?—Yes.

7544. The amount in fresh water is how much?—1·7.

7545. And the amount in sewage is how much?—10 in 100,000.

7546. Could you tell us how much you have taken as the chlorine in a combination of sewage and fresh water?—That varies in different parts of the river. I have a table here which shows that; it has not been printed, but I will put it in. That shows the quantity at every station. Below Barking it is constant, but above it is less.

7547. When you are getting down below Barking, and into the part where there is a good deal of salt water, would it make any difference to your observations to know how much is fresh water and how much is sewage?—No.

7548. For the purpose of ascertaining the relative amount of sea water and non-sea water, is it material to distinguish between the sewage and the fresh water?—No, it is not.

(*Mr. Bidder.*) In the lower reaches, where the proportion of chlorine reaches hundreds of grains, the relative proportions of fresh water and fresh water and sewage are not important.

(*Witness.*) In the other tables we have estimated river water—not Southend water,—but in the later tables you will see there is very little difference in the ratios. If you compare those with the columns in the ratios, you will find that that is taking not sea water but river water, and comparing it with Southend water. This table, as I say, shows the amount of chlorine taken all the way down the river.

(*The same was handed in, and was as follows*):—

TABLE showing the Amount of Chlorine in 100,000 Parts in the component Volume of River Water and Sewage combined at the following Places on the Thames, when the Samples were taken.

| | September 14th. | | September 22nd | | November 30th. | |
|---|---|---|---|---|---|---|
| | High Water. | Low Water. | High Water. | Low Water. | High Water. | Low Water. |
| Teddington - - | 1·7 | 1·7 | 1·7 | 1·7 | 1·7 | 1·7 |
| Chiswick - - | 1·7 | 1·7 | 1·7 | 1·7 | 1·7 | 1·7 |
| St. Paul's Pier - | 2·11 | 2·11 | 2·01 | 2·01 | 1·7 | 1·7 |
| Deptford - - | 2·34 | 2·34 | 2·17 | 2·17 | 1·77 | 1·7 |
| N. Woolwich - - | 2·58 | 2·58 | 2·35 | 2·35 | 1·86 | 1·7 |
| Barking - - | 2·67 | 2·67 | 2·42 | 2·42 | 1·90 | 1·90 |
| Crossness - - | 2·67 | 2·67 | 2·42 | 2·42 | 1·90 | 1·90 |
| Erith - - | 2·67 | 2·67 | 2·42 | 2·42 | 1·90 | 1·90 |
| Gravesend - - | 2·67 | 2·67 | 2·42 | 2·42 | 1·90 | 1·90 |
| Southend - - | 2·67 | 2·67 | 2·42 | 2·42 | 1·90 | 1·90 |

7549. I may take it that, when you get down the river, it is immaterial, for the purpose of ascertaining the amount of sea water, whether you take the amount of chlorine in what is non-sea water or in what is taken as river water and sewage?—It makes very little difference to the results.

7550. (*Chairman.*) What is the explanation of the table you have handed in? On the 14th of September the chlorine at high water and low water at Southend you put down at 2·67, and it is the same at Barking. On September the 22nd it is 2·42 at Southend, and on November the 30th it is 1·90 at Southend, can that be attributable to the difference in the quantity of the fresh river water?—That is so. There is 50 per cent. more water coming down upon the 22nd than upon the 14th, producing greater dilution in the mixture; and upon the 30th November the river was in flood.

7551. Was the quantity of flood or land water so great as to cause there being about 40 per cent. less chlorine at Southend?—Yes; the proportions on that particular day, if you will refer to the last page of my Report, are 757,000 cubic feet upon the 30th of November, and upon the 22nd of September 150,000 cubic feet per minute.

7552. Does that water bear any comparison to the volume at Southend?—No; this is the amount of chlorine in the mixed river and sewage water.

7553. For the chlorine to vary, the mixture must vary?—So it did.

7554. That is to say, there would be less chlorine; when there was 1·90, there was more land water?—Yes, there was more land water.

7555. Would its volume when it got to Southend be anything like two-fifths of the whole volume?—This is exactly worked out in proportion to the volume coming down each day.

7556. I should have thought the highest flood going over Teddington Weir would be scarcely appreciable at Southend?—It is distinctly; you will see by Table III. that it goes at low water in 13 days right away from Teddington, whereas it takes 38 days in dry weather.

(*Mr. Bidder.*) I cannot help thinking that there is some misunderstanding between your lordship and the witness as to the purpose of this table, and I will tell you why. If you look at page 4 of the tables of Professor Way's analysis of the amount of chlorine in 100,000 parts, upon the very same days the figures are so very different that I am sure this table does not mean the absolute quantity of chlorine.

(*Witness.*) I did not say it did.

(*Mr. Bidder.*) But I gathered from his lordship's question that there must be some misunderstanding as to what the table purported to show.

(*Chairman.*) I thought that if you took out any quantity of water upon one of the days named, you would have 2·67 parts of chlorine in it; and if you took it out upon another day you would have 1·90.

(*Mr. Bidder.*) If you refer to page 4 of the table of Professor Way's analysis, which relates to the very same days and the same places, you will see that that cannot be so.

(*Witness.*) I have told you what it is; that it is the chlorine in the mixed river water and sewage; it is not the chlorine in the river, you must deduct the chlorine in sea water from the actual chlorine observed in the water. My table shows the amount of chlorine in the river and sewage water combined together, and the difference between one table and the other would represent how much is made up of sea water, that being the difference, and it would show you the ratio of the sea water to the mixture.

7557. (*Chairman.*) I understand you do not dip your bucket into the water at Sheerness and try what is there then?—That is the way we originally arrived at it; then we treat it by analysis and bring out how much is really due to river water and sewage only.

(*Mr. Bidder.*) I fancy it comes to this; upon the 14th of September, at Southend, a sample bucket of water was taken, and it was found to contain at high

water 1,931 grains of chloride of sodium; that was the actual observation. Then from other considerations they drew the inference that only one part in 100, or something of that kind, of that was river and sewage water, and consequently they drew the second inference that if their first inference was correct there would be that amount of chlorine in the river and sewage water, is that right?

(*Witness.*) I have already told you that it is based upon the inference that there are five cubic feet of sewage per head of the population, and that there is a given volume of fresh water coming down the river, and that by mixing them in the proportions named you get at those results, except where you deal with the district above Barking. We see that the sea water is carried up to a certain point, and that there, there ceases to be so much chlorine. Chiswick may be taken as the vanishing point, at Barking there is the full volume, and if you take the mean between the two, it would show that there is only half the chlorine due to sewage in that part of the river which is observed at Barking.

7558. (*Mr. Lumley Smith.*) Professor Way's table is taken from actual analyses of water taken from the river?—Yes.

7559. The table that you have handed in is from that table?—This table shows the quantity of river water in the mixture all the way up the river, it is calculated from the volume of water in the river.

(*Chairman.*) What is the general conclusion which the witness draws from this? Does he say that in ordinary tides, for instance, such a part of the total volume of water at Chiswick is sea water; at Vauxhall Bridge such a proportion is sea water, and so on. If he could tell us that, it would assist us towards considering how much sewage water had got up there.

7560. (*Mr. Lumley Smith to the Witness.*) Are you able to answer that?—Yes, I show you that; I show you at every point up the river how much sea water there is.

7561. (*Chairman.*) What table is that shown by?—The table I put in yesterday.

7562. That is to say, at Chiswick, $\frac{1}{700}$th part of the volume was sea water?—Yes.

7563. At St. Paul's Pier about $\frac{1}{3}$th was sea water, is that so?—We give you the exact ratio of the mixture in the fifth column.

7564. When you get to Erith you find about an equal quantity of sea water and of the mixture of sewage and fresh water?—Yes, that is so.

7565. (*Mr. Lumley Smith.*) That gives you, as shown in your table, what, in your opinion, is the actual ratio of sea water and non sea water at those different points of the river?—Yes, it does; but this is, of course, upon the assumption which I explained yesterday. I made the calculations upon the basis that all the water came in at Teddington; it was a much longer work to take it out at all the points coming down the river, but I have now had that done.

7566. These tables which you now hand in carry out the same calculation as those you handed in yesterday, except that it is much more accurately worked out?—Yes.

7567. What is the conclusion at which you have arrived?—That it increases the number of days which it takes the sewage to get out, but it does not affect it all below Barking; it affects it more above, in the upper reaches of the river. (*See table inserted after* Q. 7369.)

*Mr. B. Latham M. Inst. C.E.*

24 Jan. 1883.

TABLES showing the effect of the mixing action in the River Thames. These results are obtained by taking sewage as containing 10, river water 1·7, and sea water 1,961 parts of chlorine in 100,000 parts.

SEPTEMBER 14TH, 1882.

| — | Distance. | Mean flow of River Thames on September 14th. | High Water. | | | Low Water. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean sectional Area of Fresh Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. | Mean sectional Area of Fresh Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. |
| | | C. ft. per m. | | Days | Days | | Days | Days |
| Teddington to Chiswick. | 48,405 | 84,543 | 6,002 | 2·38 | 2·38 | 1,812 | ·72 | ·72 |
| Chiswick to St. Paul's Pier. | 48,389 | 86,609 | 14,464 | 5·61 | 7·99 | 4,727 | 1·83 | 2·55 |
| St. Paul's Pier to Deptford. | 24,874 | 87,574 | 23,134 | 4·56 | 12·55 | 9,627 | 1·90 | 4·45 |
| Deptford to N. Woolwich. | 29,188 | 89,004 | 28,639 | 6·52 | 19·07 | 14,827 | 3·37 | 7·82 |
| N. Woolwich to Barking. | 9,156 | 91,570 | 35,652 | 2·47 | 21·54 | 19,875 | 1·38 | 9·20 |
| Barking to Crossness. | 13,620 | 101,057 | 40,433 | 3·78 | 25·32 | 22,907 | 2·14 | 11·34 |
| Crossness to Erith. | 14,227 | 109,439 | 43,000 | 3·88 | 29·20 | 28,772 | 2·60 | 13·94 |
| Erith to Gravesend. | 57,570 | 112,535 | 39,906 | 12·70 | 41·90 | 35,622 | 11·33 | 25·27 |
| Gravesend to Southend. | 90,081 | 116,822 | 22,468 | 12·03 | 53·93 | 37,640 | 20·15 | 45·42 |

SEPTEMBER 22ND, 1882.

| — | Distance. | Mean flow of River Thames on September 22nd. | High Water. | | | Low Water. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean sectional Area of Fresh Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. | Mean sectional Area of Fresh Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. |
| | | C. ft. per m. | | Days | Days | | Days | Days |
| Teddington to Chiswick. | 48,405 | 123,550 | 4,353 | 1·18 | 1·18 | 1,975 | ·53 | ·53 |
| Chiswick to St. Paul's Pier. | 48,389 | 125,504 | 12,019 | 3·22 | 4·40 | 5,559 | 1·49 | 2·02 |
| St. Paul's Pier to Deptford. | 24,874 | 126,420 | 20,882 | 2·85 | 7·25 | 11,515 | 1·57 | 3·59 |
| Deptford to N. Woolwich. | 29,188 | 128,801 | 26,638 | 4·19 | 11·44 | 17,695 | 2·78 | 6·37 |
| N. Woolwich to Barking. | 9,156 | 132,410 | 33,623 | 1·61 | 13·05 | 23,941 | 1·15 | 7·52 |
| Barking to Crossness. | 13,620 | 141,942 | 39,597 | 2·64 | 15·69 | 28,014 | 1·86 | 9·38 |
| Crossness to Erith. | 14,227 | 150,423 | 44,106 | 2·89 | 18·58 | 33,999 | 2·23 | 11·61 |
| Erith to Gravesend. | 51,570 | 152,833 | 44,237 | 10·37 | 28·95 | 40,445 | 9·48 | 21·09 |
| Gravesend to Southend. | 90,081 | 156,380 | 31,771 | 12·71 | 41·66 | 36,162 | 14·46 | 35·55 |

NOVEMBER 30TH, 1882.

| — | Distance. | Mean flow of River Thames on November 30th. | High Water. | | | Low Water. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Mean sectional Area of Fresh Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. | Mean sectional Area of Fresh Water and Sewage combined. | Time occupied by Fresh Water and Sewage in traversing River. | Total Time from commencement. |
| | | C. ft. per m. | | Days | Days | | Days | Days |
| Teddington to Chiswick. | 48,405 | 480,667 | 5,762 | ·40 | ·40 | 2,851 | ·20 | ·20 |
| Chiswick to St. Paul's Pier. | 48,389 | 487,260 | 14,813 | 1·02 | 1·42 | 5,617 | ·39 | ·59 |
| St. Paul's Pier to Deptford. | 24,874 | 489,715 | 26,538 | ·93 | 2·35 | 10,155 | ·36 | ·95 |
| Deptford to N. Woolwich. | 29,188 | 500,049 | 37,057 | 1·50 | 3·85 | 15,852 | ·64 | 1·59 |
| N. Woolwich to Barking. | 9,156 | 513,612 | 49,889 | ·61 | 4·46 | 22,990 | ·28 | 1·87 |
| Barking to Crossness. | 13,620 | 527,537 | 60,186 | 1·08 | 5·54 | 29,247 | ·52 | 2·39 |
| Crossness to Erith. | 14,227 | 539,543 | 70,321 | 1·29 | 6·83 | 38,612 | ·70 | 3·09 |
| Erith to Gravesend. | 51,570 | 549,089 | 70,167 | 12·57 | 19·40 | 65,617 | 11·75 | 14·84 |
| Gravesend to Southend. | 90,081 | | | | | | | |

*Mr. B. Latham. M. Inst. C.E.*

24 Jan. 1883.

7568. Do you draw any conclusion as to the number of days in which the sewage will get out to sea?—Yes.

7569. Will you tell us, generally, what conclusion you draw with regard to that?—The conclusion we draw from this amended table is this, that, if we take the high water on the 14th of September, and start at Deptford, it would take 41 days to get out; and, taking low water, it would be, roundly, 40 days. Then, upon the 22nd. of course it goes much quicker, there being a much larger quantity of water in the river, and it takes, roundly, 34 days from Deptford, at high water, and at low water, 31 days. Upon the 30th of November it takes, roundly, 16 days at high water, and it takes 12 days at low water. In a very dry time of course, it would go out very much more slowly, as is shown by these results.

7570. When you speak of the high water upon a particular day, you mean that the sewage which is discharged from the outfalls upon that particular day at the top of the tide would get to the sea in the time that you have mentioned?—Yes. I have taken Deptford, because, as a fact, the sewage is discharged for about three hours, and it is brought up again, as a rule, to this point upon the top of the returning tide.

7571. By taking the high tide you take the first sewage which is poured in?—I take the point at which the sewage arrives, after it has been discharged, upon the next tide.

7572. When you speak of high water, that is when the sewage was discharged at high water when the reservoir was opened?—Sewage discharged at high water and down to half tide.

7573. The sewage discharged at the intermediate time would, I presume, arrive at the intermediate time at the sea?—It would arrive at an intermediate time in the lower part of the river, and at a higher point upon the return.

7574. In arriving at the time when the sewage would get to the sea, have you considered both the displacement and the mixing?—Yes; displacement is a very slow operation indeed; the displacement is simply due to the upland water pushing the water out of the river.

7575. And that, as my Lord pointed out, would take a long time, if that alone had to get it into the sea, but in flood time it would have a considerable effect?—In flood time the flood has effect by displacing more quickly, and also the mixing action being greater.

7576. Have you calculated the difference between the mixing action in flood and dry times?—I show the difference between flood and dry times to be 30 times, taking the whole basin of the Thames.

7577. Are you speaking of the whole of the water?—No; I am comparing 12 feet per square mile of the whole drainage area with 360 feet per square mile in flood time.

7578. Now, I want to ask you a question or two about some matters which may go to cause pollution in the River Thames. I believe there was published in the published reports, and, indeed, we have heard from Sir Joseph Bazalgette, what was the amount of sewage which was proposed to be taken in the sewers and the amount of rainfall also?—Yes, that has been stated.

7579. I believe you have made some calculations for the purpose of showing that the population has outgrown the population which the sewers were estimated to be able to accommodate?—That is so.

7580. Have you also made some calculations which tend to show that the amount of rainfall which the sewers can take is below what really gets into them?

(*Sir John Coode.*) But Sir Joseph Bazalgette has told the Commission that the Metropolitan Board of Works were prepared to spend a million and a half of money to remedy this evil.

(*Mr. Lumley Smith.*) I hope to be able to show from calculations we shall produce that a great quantity of sewage, and rain mixed with sewage, does habitually go into the river in London, which would, I submit, appear to be material, in considering how far the present system of sewerage is sufficient, or how far it requires amendment. I further intend to show that pollution takes place partly from the outfalls and partly from what happens above the outfalls.

(*Chairman.*) Certainly, that is a very proper matter of inquiry.

(*Sir John Coode.*) These remarks apply to Pimlico and Battersea.

(*Mr. Lumley Smith.*) Yes.

(*Mr. Bidder.*) But surely, with submission, the question is not what our system is, and what our population is, and whether it is calculated for that population or not; but, being what it is, what effect it has upon the river at this point.

(*Chairman.*) I suppose it is a sort of evidence against you, in this way, that you would not have wasted your means in making larger sewers than you thought necessary, that is if you thought that sewers for two millions only were necessary.

(*Mr. Bidder.*) But, my Lord, even supposing we assume that the Metropolitan Board of Works thought accommodation for two millions was sufficient, and we have now to provide for four millions, how does that affect the question; the question is, what is its effect upon the river?

(*Chairman.*) They propose to show that the thing being what it is it is not sufficient, and they propose to show it in this way, that you, yourselves, thought that all you would have to provide for was two millions, and you provided for two millions, and now there are four millions, and, therefore, you have not provided what you would have done if you had known what would happen.

(*Mr. Bidder.*) But, if I may say so, is not the question as a matter of fact, what is the effect of the sewage system upon the river Thames, is not that the point?

(*Chairman.*) You, yourselves, will show that you would not have done then what you have done now, if you had known then what you know now. I think when Sir Joseph Bazalgette comes he will be asked that question.

(*Sir John Coode.*) We have to inquire into the facts as they now exist.

7581. (*Mr. Lumley Smith to the witness.*) In order to take it a little systematically, will you tell me, if you please, what you take to be the area drained by the sewers of the metropolis. I believe you first of all take your figures, do you not, from the report of the Metropolitan Board of Works of the 31st of December 1874?—Yes, that is so; the report to Parliament.

7582. Will you tell me what is the area stated to be draining into the Northern high level sewers?—The area draining into the Northern high level sewer is stated to be 10 square miles, into the Middle level sewer 17½ miles, into the low level 11 miles, and into the western district 14½ miles, making a total of 53 square miles.

7583. What is the area stated to be draining into the sewers upon the south side?—In the south the area draining into the high level sewer is 20 miles, and into the low level sewer 20 miles, making a total of 40 square miles.

7584. That would make a gross total of 93 square miles?—Yes, a total of 93 square miles, I should mention that there was another figure given before, in what is known as the "Mud inquiry," which made the south 42, and the north 51; it was the same total, but it made the incidence different.

7585. You have checked it yourself, have you not, from the Ordnance map?—From the Ordnance Survey.

7586. Can you give us the actual area by calculation, which is under the jurisdiction of the Board of Works?—Yes, the area upon the north of the Thames I have divided into land and water and foreshore. The area in Middlesex upon the north is 49·19 square miles, and in Kent ·64.

7587. Making a total of land of how much?—Of 49·83, and of water and foreshore in Middlesex 1·45 square miles, and in Kent ·40, making a total of 1·85.

7588. That makes a total area north of the Thames of how much?—Of 51·68 square miles within the jurisdiction of the Metropolitan Board of Works.

7589. And south of the Thames?—South of the Thames we have of land 37·34 square miles in Surrey; 30·70 square miles in Kent; making a total of land 68·04 square miles; of water and foreshore ·99 in Surrey, and 1·39 in Kent; making a total of 2·38, or a total upon the south side of 70·42 square miles.

7590. That gives a grand total of land of 117·87; and of water and foreshore of 4·23; making a total of 123·1 square miles?—Yes.

7591. I believe that agrees pretty accurately, does it not, with the Registrar General's returns?—That agrees very nearly with the Registrar General's returns, which work out from the acreage given in these returns at 122 square miles.

(*Mr. Bidder.*) Is "area under the jurisdiction of the Board" the same thing as "area drained by the Board?"

7592. (*Mr. Lumley Smith.*) I am coming to that. *To the witness.*) I see your total area of land, 117·87, agrees with the Metropolitan Board of Works' reports; what do they make it?—They give it in one report as 117½, and in another at 118.

7593. As the amount drained is given as 93 square miles, there is, apparently, a difference between the amount drained and the amount under their jurisdiction of 24½ miles?—Yes, that is of land only, deducting the foreshore and water.

7594. Then they have within their jurisdiction, which would have to come into their system, about 24½ miles?—Yes, principally upon the south side of the river.

7595. I presume it was considered unnecessary to drain that part?—I do not know as to that.

7596. In addition to the natural drainage from the 93 miles, are there any other matters which come into the sewers of the metropolis?—Yes.

7597. First of all, I will direct your attention to the natural streams, do the natural streams affect the question?—Yes. Before the metropolis became what it now is, the whole district was divided into valleys, which had natural streams within them. In the Metropolitan district, most of the streams in the valley lines have been converted into sewers. The upper end of the streams terminated in districts outside the metropolis, so that whatever portion of the district outside the metropolis is in their watershed must naturally drain into the Metropolitan Board sewers, such, for example, as the Effra and the Stamford Brook.

7598. These rivers have their source outside the Metropolitan district, so that the water which enters the streams outside the metropolitan district has to be conveyed through the metropolitan sewers to the river Thames?—It has.

7599. I do not know whether there is any means of estimating the amount of water that comes in from these brooks?—It can be estimated, whatever it is, it has to be conveyed, it cannot be limited to any specific quantity; whatever rain falls, and flows down the stream must go into the sewer; it may be 2½ inches in 24 hours, or it may be very much less.

7600. All that has to be added to what is naturally taken by the sewers?—Yes.

7601. Then there are other districts which have to be added to the metropolitan districts?—Yes; those are districts which, for the purpose of rainfall, comprise a part of Chiswick, ·13 of a square mile; Ealing detached, which is Bedford Park, ·88 of a square mile; Acton, 3·52 square miles; Hornsey, ·64 of a square mile; Willesden, ·75 of a square mile; making, upon the north, 6·92 square miles. Then part of Croydon, Upper Norwood, ·46, and Beckenham, 1·05; making 1·51 miles in the south; making a total outside the metropolis of 8·43 square miles. The whole of the rainfall of that 8·43 square miles has to pass into the metropolitan sewers, as it can go no where else.

7602. Are those legally drained into the metropolitan system, or is it a matter of dispute; I believe some Act of Parliament has been acquired?—That is as to the rainfall only, but in addition to that there are those districts which drain their sewage into the metropolitan sewers.

7603. Those districts may be built over, or they may not be; can you give us any idea of the amount which comes from those districts?—In 1871 an Act of Parliament was passed, which enabled Hornsey to drain in, that is take the whole of the district. That part of Hornsey I have been dealing with is only the part of the district which drains the rainfall into the sewer, but in 1871 an Act was passed to admit the sewage of this district, and they were limited in the Act to pass 500 cubic feet a minute, that is at the rate of four and a half millions cubic feet in 24 hours into the metropolitan sewers. In 1878 an Act was passed to enable Beckenham Tongue, which contains 675 acres, to drain in; and in 1874, under another Act, the South Hornsey Local Board district was drained, and by a recent decision a very large part of Acton was admitted.

7604. I believe the admission of Acton is the result of litigation, is it not?—It has been, but I believe it is settled now.

7605. (*Mr. Bidder.*) I believe an injunction has been granted against the Local Board of Acton, prohibiting any future extension of drainage into the Board of Works sewers, while it authorised that which had existed previously?—That is so; that all the existing drainage goes in, but none in the future can go in. I have also got at the population of those places. The population of Hornsey in 1881 was 22,474; and of South Hornsey 14,587, part of Acton is estimated at 14,000, part of Croydon at 3,000, and part of Beckenham at 5,000, making a total of 59,061.

7606. (*Mr. Lumley Smith.*) Then you have treated these districts as having all to be drained into these sewers?—They have to be drained into these sewers.

7607. Do you find anywhere in the Board's reports anything to show that this was contemplated?—No; it has been reported to Parliament that these powers have been taken from time to time, but were not in the original scheme.

7608. (*Chairman.*) Would the natural water, the rainfall, from these districts, have gone through the sewers even if the sewage had not?—The rainfall is in addition to what I have been speaking of, it must go through; it is its natural outlet, but that does not apply to Hornsey. A very small part of it would have gone into the sewers by gravitation.

7609. Would some of it have gone into the Lea?—Some of it would have gone into the Lea; the largest portion.

7610. (*Mr. Lumley Smith.*) The privilege of sending sewage down the metropolitan sewers is one thing which could not have been done without the authorization of Parliament, but you yourself said that there were certain places not sewered to the metropolis, the rain water of which nevertheless must find its way through the sewers. Do those additional places which you mention, which have now the privilege of draining their sewage through the metropolitan sewers, add not merely their sewage to the sewers but their rainfall, or was the rain water there before?—In Chiswick no sewage goes in, but the natural rainfall only. At Norwood, both the sewage of the district and the rainfall go in.

7611. Formerly the rainfall went in and not the sewage?—Yes. At Ealing (Bedford Park) both the rainfall and the sewage go in.

7612. Have they had the privilege of draining their sewage into the sewers?—That has been added.

7613. What is the consequence of that; that the rainfall goes into the sewers which it did not do before, or merely that sewage goes in which did not go in before?—The rainfall went in before, and now the sewage goes in in addition. In Hornsey only a portion of the rainfall and all the sewage goes in.

7614. It is not to be taken from what you say that the sewers now drain additionally, if one may say so, all those places; they take their sewage now, but they drained them, or many of them, before of the

*Mr. B. Latham, M. Inst. C.E.*

24 Jan. 1883.

rainfall?—Small portions of them. Beckenham takes no rain water in, only the sewage and the rain water which falls upon the roofs of the houses, but in the case of the other districts, the 8·4 square miles, all the rainfall has to go into the sewers.

7615. (*Mr. Bidder.*) Would you mind adding one thing to that, that it always had to go in?—It always had to go in; it is part of the natural drainage area.

7616. (*Mr. Lumley Smith.*) Now if you please, with regard to population; do you find in any Report of the Metropolitan Board what the population provided for was?—Yes.

7617. Will you tell us where you find that?—In the report that you have before you of the 6th of April 1858, page 41.

7618. Whose report is that?—It is the report of Messrs. Bidder, Hawksley, and Bazalgette.

7619. What do you find stated there with regard to the provision made for future population?—In the north the population provided for was 2,353,900, and in the south 1,094,600, making a total of 3,448,500.

7620. That represents, as I understand, the population to be provided for in the sewers?—That represents the population which the sewers were designed to provide for.

7621. Not the existing population of the day, but the future population?—Not the existing population of the day, but the future population as then estimated.

7622. I believe there is a district called the Western District?—There is such a district.

7623. What do you include in that?—It is shown on one of the plans in this report I have just alluded to, coloured green.

7624. What district is it roughly?—It is a district which comprised 14½ square miles, as described in the report of 21st January, 1854.

7625. Is there anything which shows that in that estimated future population of 3,448,500 the western population is included?—There is nothing to show that, but these figures contemplated the whole population upon the north and the whole population upon the south.

7626. Have you anything to show or can you give us any reason for supposing that that was to include the drainage of the western district?—There is a report of Sir Joseph Bazalgette and Colonel Haywood of the 21st January 1854, which brings it in.

7627. What is stated there with regard to the prospective population to the north?—They had dealt separately with that, and they pointed out that as being 2,013,200 as against the 2,353,900 for the whole of the north.

7628. Does that report give the population for the Brentford and Acton Divisions?—Yes; at that time the Board evidently contemplated going much higher up the river.

7629. What did they make the population of the western area?—553,900.

7630. That would make the population to the north with the western area, 2,567,100?—That is so.

7631. That is a little larger than is given in the report of Messrs. Bidder, Hawksley, and Bazalgette?—Yes, because it included a rather larger district.

7632. Is it fair to conclude that the prospective population given in 1858 included the western district?—It included the western district.

7633. We will come to the district as we find it to be; you have taken the census of 1881, have you not?—I have taken the census of 1881, and I find that by that census the population of the north was 2,543,999, and of the south it was 1,283,448, making a total of 3,832,441.

7634. Therefore at the time of the census do you find an excess of population in the metropolis beyond the figures mentioned in the provisional estimate?—Yes, I find that there was an excess in the metropolis upon the north of 195,093, and upon the south of 188,448 beyond what was contemplated.

7635. Ought anything to be added for the district outside?—Yes, you must add to the population I have already given 50,000 for the districts outside draining into the metropolitan district.

7636. (*Chairman.*) As far as the sewage goes does it appear whether you have calculated it upon this hitting the exact amount or whether they had left a margin?—As regards mere sewage it is based upon these figures in a way which I will presently explain.

7637. (*Mr. Lumley Smith.*) Adding so much for the districts outside the metropolis, what have you got for the figures of the population in 1881?—If you add 50,000 of course it shows you that there is in round numbers nearly half a million of people more in the metropolis and the districts outside draining into these sewers than the sewers were contemplated to deal with.

7638. Is that what you find from the census or is that your estimate for the present year 1882?—That is calculated to the middle of 1882.

7639. What did you find it was at the time of the census?—433,000.

7640. Now you have given us, have you not, the population of the Metropolitan Board's district?—I have.

7641. A distinction seems to exist between the space drained and the whole district?—Yes, there is such.

7642. Will those figures require any correction for the purpose of making them the figures of the district drained as distinguished from the district under the jurisdiction of the board?—Yes; not so much on the north, but on the south more so; and I will here put in two tables, one which shows the district of the Registrar-General which coincides more nearly with the district which is actually drained, and a second table in which I have put in the population of the Metropolitan Board district itself from 1871 to 1881, the figures of which have been arrived at from the census periods. Then I give a calculation taking the same rate of increase as was found to exist in the metropolis between 1871 and 1881, and continuing it, by which I give you the probable population every year up to 1901, both upon the north and south of the river.

*The following tables were handed in.*

POPULATION within the LIMITS of the REGISTRAR-GENERAL'S DISTRICT* on the NORTH and SOUTH of the METROPOLIS.

| Year. | North London. | South London. |
|---|---|---|
| 30 June 1871 | 2,292,597 | 973,978 |
| „ „ 1872 | 2,317,777 | 1,000,491 |
| „ „ 1873 | 2,343,233 | 1,027,726 |
| „ „ 1874 | 2,368,968 | 1,055,701 |
| „ „ 1875 | 2,394,986 | 1,084,439 |
| „ „ 1876 | 2,421,290 | 1,113,958 |
| „ „ 1877 | 2,447,882 | 1,144,282 |
| „ „ 1878 | 2,474,766 | 1,175,429 |
| „ „ 1879 | 2,501,946 | 1,207,427 |
| „ „ 1880 | 2,529,425 | 1,240,294 |
| „ „ 1881 | 2,557,205 | 1,274,058 |

* The population of this district has been used in all calculations, it more nearly coincides with the area actually sewered.

ESTIMATED PROSPECTIVE POPULATION from 1882 to 1901, at the same RATE of INCREASE.

| Year. | North London. | South London. |
|---|---|---|
| 30 June 1882 | 2,585,290 | 1,308,738 |
| „ „ 1883 | 2,613,684 | 1,344,363 |
| „ „ 1884 | 2,642,390 | 1,380,958 |
| „ „ 1885 | 2,671,411 | 1,418,551 |
| „ „ 1886 | 2,700,751 | 1,457,164 |
| „ „ 1887 | 2,730,413 | 1,496,830 |
| „ „ 1888 | 2,760,400 | 1,537,575 |
| „ „ 1889 | 2,790,717 | 1,579,429 |
| „ „ 1890 | 2,821,367 | 1,622,423 |
| „ „ 1891 | 2,852,354 | 1,666,587 |
| „ „ 1892 | 2,883,681 | 1,711,957 |
| „ „ 1893 | 2,915,351 | 1,758,559 |
| „ „ 1894 | 2,947,370 | 1,806,425 |
| „ „ 1895 | 2,979,741 | 1,855,598 |
| „ „ 1896 | 3,012,468 | 1,906,109 |
| „ „ 1897 | 3,045,552 | 1,957,995 |
| „ „ 1898 | 3,079,001 | 2,011,294 |
| „ „ 1899 | 3,112,817 | 2,066,044 |
| „ „ 1900 | 3,147,005 | 2,122,284 |
| „ „ 1901 | 3,181,567 | 2,180,055 |

POPULATION of NORTHERN and SOUTHERN LONDON—METROPOLITAN DIVISIONS—interpolated for the 30th June of each year, between 1871 and 1881.

| Year. | North. | South. | Total. |
|---|---|---|---|
| 1871 | 2,291,687 | 985,737 | 3,277,424 |
| 1872 | 2,316,805 | 1,012,751 | 3,329,556 |
| 1873 | 2,342,198 | 1,040,505 | 3,382,703 |
| 1874 | 2,367,869 | 1,069,020 | 3,436,889 |
| 1875 | 2,393,822 | 1,098,317 | 3,492,139 |
| 1876 | 2,420,060 | 1,128,416 | 3,548,476 |
| 1877 | 2,446,585 | 1,159,340 | 3,605,925 |
| 1878 | 2,473,400 | 1,191,111 | 3,664,511 |
| 1879 | 2,500,510 | 1,223,753 | 3,724,263 |
| 1880 | 2,527,917 | 1,257,290 | 3,785,207 |
| 1881 | 2,555,624 | 1,291,745 | 3,847,369 |

PROSPECTIVE POPULATION at the same RATE of INCREASE until 1901.

| | | | |
|---|---|---|---|
| 1882 | 2,583,635 | 1,327,145 | 3,910,780 |
| 1883 | 2,611,953 | 1,363,515 | 3,975,468 |
| 1884 | 2,640,581 | 1,400,882 | 4,041,463 |
| 1885 | 2,669,523 | 1,439,273 | 4,108,796 |
| 1886 | 2,698,782 | 1,478,716 | 4,177,498 |
| 1887 | 2,728,362 | 1,519,240 | 4,247,502 |
| 1888 | 2,758,266 | 1,560,874 | 4,319,140 |
| 1889 | 2,788,498 | 1,603,650 | 4,392,148 |
| 1890 | 2,819,061 | 1,647,597 | 4,466,658 |
| 1891 | 2,849,959 | 1,692,749 | 4,542,708 |
| 1892 | 2,881,196 | 1,739,138 | 4,620,334 |
| 1893 | 2,912,775 | 1,786,799 | 4,699,574 |
| 1894 | 2,944,700 | 1,835,766 | 4,780,466 |
| 1895 | 2,976,975 | 1,886,075 | 4,863,050 |
| 1896 | 3,009,605 | 1,937,762 | 4,947,367 |
| 1897 | 3,042,592 | 1,990,866 | 5,033,458 |
| 1898 | 3,075,940 | 2,045,425 | 5,121,365 |
| 1899 | 3,109,654 | 2,101,480 | 5,211,134 |
| 1900 | 3,143,737 | 2,159,070 | 5,302,807 |
| 1901 | 3,178,194 | 2,218,239 | 5,396,433 |

BASIC FIGURES of the CENSUS RETURNS employed in these COMPUTATIONS.

| | | | |
|---|---|---|---|
| 3 April 1871 | 2,285,672 | 979,333 | 3,265,005 |
| 4 April 1881 | 2,548,993 | 1,283,448 | 3,832,441 |

7643. Now, is it the fact that the limits of the Registrar-General's district coincide more nearly with the district actually sewered?—They do.

7644. You can tell us in a moment what is the definition of the district of the Registrar-General; is that defined by Act of Parliament and is it what is known as the Bills of Mortality district?—It is what they call the Bills of Mortality district.

7645. And that corresponds more nearly with the district sewered?—It corresponds more nearly with the district sewered than the Metropolitan Board's district population itself does.

7646. I see that in 1881 the population exceeds the figure that you gave us of the population in the Metropolitan Board's district; will you compare the figure you gave us in 1881 in the Board's district with the Registrar General's district?—There is a very much larger area outside the Metropolis on the north which comes into the sewers, while on the south there is a very large area which is not drained, and when you compare the two statements of population upon the south you will find that in the Registrar General's district they are much less than in the Metropolitan district.

7647. You say that upon the north it is very much the same thing—that the whole of the district is sewered?—It is not only sewered but the district outside is sewered—there is a small margin, but it is all more or less built upon at the present time.

7648. According to your calculation the population in the middle of 1882 exceeds what the sewers have been provided for by about half a million?—Yes.

7649. If the present increase is continued (that is on the north only) there would be an increase of 100,000 in the present year; is that so?—No, that is taking both north and south.

7650. And in 20 years' time there will be an increase of how much?—A very considerable increase.

(*Sir John Coode.*) The witness makes it 5,360,000, taking the figures in the first Table.

7651. (*Mr. Lumley Smith.*) So much for the population. Now can you tell us the increase in the rateable value of the Metropolis between 1856 and 1882; what was the rateable value in 1856?—The rateable value has increased from about 11,000,000 to 27,000,000 of money in round numbers.

7652. Now a question or two about the rainfall; what amount of rainfall was provided to be dealt with?—The amount of rainfall to be dealt with is shown in that Report I have quoted, and it is also given in the Government Returns; on the north it was 28,500,000 cubic feet in the day, and upon the south 17,250,000 cubic feet in the day.

7653. That you find by the Report as what was to be provided for?—Yes, it is at page 44 of the same Report and it is also given in the Report to Parliament of the 31st December 1874.

7654. I think it was also stated what quantity as regards the areas should be taken?—It was stated that a quarter of an inch of rain flowing off the area was to be taken.

7655. That agrees with what was stated by Sir Joseph Bazalgette in his answer to question 9 upon the first day of this inquiry?—Yes.

7656. Do you find in that Report during what period the quarter of an inch is estimated for?—The quarter of an inch is estimated as flowing off uniformly throughout the 24 hours, or in round numbers one-hundredth of an inch an hour during the maximum period of the flow of the sewage.

7657. Is the time of maximum flow of the sewage given?—Yes, that has been given; being calculated at half the total volume (which was taken at five cubic feet per head) flowing off in six hours.

7658. The sewage flows unevenly; we may take it as half flowing off in six hours, and half in the remaining 18 hours?—That was what was stated in the Metropolitan Board of Works report, but the Government Referees' report took half the flow as passing off in eight hours.

7659. What does a quarter of an inch a mile represent?—580,800 cubic feet.

7660. Then if you divide that figure that was given you as the rainfall from the north of the metropolis, for which provision was made by that quantity, what is the result?—If you divide the 28,500,000 cubic feet, which is stated to be the quantity of rain that the sewers are to carry by the 580,800 cubic feet, that being the quantity which a quarter of an inch of rain flowing off would give, that shows that the area is 49·07 square miles.

7661. Is that quarter of an inch of rainfall a matter of calculation?—It is a matter of calculation. Having got the quantity the sewers are to carry and the time in which they are to carry it, it is only a matter of calculation as to the area.

7662. Then treating the south in the same way, what do you find to be the result?—Treating the south in the same way, we have the quantity there given as the amount of rain which is to be admitted to the sewers at 17,250,000 cubic feet; that divided by the 580,800 shows that the area must have been 29·7 square miles.

7663. (*Chairman.*) And what is the actual area?—The actual area which has been given in the reports I have referred to was 40 square miles and 53 square miles on the north.

7664. (*Mr. Lumley Smith.*) It appears that the provision made for the south was for a very much smaller district than should have been provided for assuming that depth of rain to be taken?—Yes.

7665. But I believe you do find that a reason is given in the report for taking a smaller amount?—I find in some of the earlier reports that a reason is given for taking a smaller amount.

7666. What is that reason?—That from the northern high level and from the high level district upon th

*Mr. B. Latham, M. Inst. C.E.*

24 Jan. 1883

south instead of taking a quarter of an inch, they took only an eighth of an inch of rain.

7667. Can you give us the reference in Sir Joseph Bazalgette's report to that?—It is the report of the 13th of April 1856 to the Metropolitan Board of Works. It is stated that, "In the thinly populated "suburbs only one half the quantity of rain for "which provision is made in the more crowded dis- "tricts is to flow of."

7668. In the south it may be that the larger area was contemplated, but the smaller amount has been taken; that is to say, one eighth instead of a quarter?—One eighth has been taken in both these high levels, because if you take the eighth of an inch from the high level area it practically comes to the 40 square miles which they have admitted in the south.

7669. It comes to this, that a quarter of an inch is taken in the 24 hours, except in the high levels where one eighth has been taken?—Yes.

7670. That is independent, is it not, of the outside district?—That is entirely independent of the outside district. It is based merely upon the volume which they have given us which the sewers are to carry, which is clearly calculated only upon the metropolitan area itself.

(*Chairman to Mr. Lumley Smith.*) This tends to show two things, does it not. First of all, that the sewers must be discharging, perhaps at the time when the tide is not ebbing, but more especially it shows that the overflows carry the sewage and everything direct into the river.

(*Witness.*) That is really the bearing of the whole question, that it leads to the pollution of the higher portions of the river, and that by discharging more frequently at other points into the river there is an accumulation of the sewage which would not otherwise take place.

(*Mr. Lumley Smith.*) When a storm outlet opens out comes the sewage and storm water together.

(*Chairman.*) That raises quite a different question as to whether they have gone low enough, but it also raises this question—whether they must not separate their rain drains from their sewage drains?

(*Mr. Lumley Smith.*) That is so; that is when you come to the remedy.

(*Mr. Bidder.*) As regards the storm outlets I should point out that the storm outlets were part of the original scheme, and were made with the intention that they should come into operation; and when they do come into operation, which is when there is heavy rain, their operation must be necessarily that which has been described. That was their intended operation, and whether it is a nuisance or not is another matter. That there should be storm overflows is no unforeseen matter.

(*Chairman.*) No, we understood that from Sir Joseph Bazalgette. He explained the whole thing as well as anything could be done, I thought.

7671. (*Mr. Lumley Smith to the Witness.*) Now you say the Board put down the time of the maximum flow of the sewers at six hours; you put it at eight, do you not?—I say the Board in their calculation take six hours for the maximum flow. The gaugings of the sewers, published by the Government Referees in their Report in 1857, showed that half of it flowed off in eight hours instead of six. Recent experiments, however, show that half of the whole volume of the sewage flows off in nine hours.

7672. (*Chairman.*) Supposing that the reservoirs were entirely empty, and you started quite fresh, half the sewage put in would reach them in nine hours?—Half the sewage of the Metropolis, as distinguished from rainfall, would reach them in nine hours of maximum flow.

7673. (*Col. Ewart.*) At the two outfalls?—These calculations are based upon the southern outfall. We do not know anything at all of the northern.

7674. (*Chairman.*) The sewage is perpetually coming into the sewers of course in the whole 24 hours?—That is so.

(*Mr. Lumley Smith.*) But the evidence is that there is very little at night.

(*Mr. Bidder.*) Your Lordship will find that there are certain periods of the day in which there is a great flow of sewage, and other periods of the day in which the flow of sewage is very small. Sir Joseph Bazalgette was quite right in laying down his plans. He assumed that the contrast would be so great that he would have to deal with half the sewage in six hours of the day, and, consequently, he must make his sewers proportionately big, but in point of fact it turns out that there are nine hours over which that flow is distributed, so that he has rather made his sewers too big than too small.

(*Witness.*) I may say that I have paid great attention to the rates of fluctuation in sewers, and knowing that a table was published in the Mud Inquiry of the gaugings of the sewage flowing out at Crossness I was able to work out from my experience what this table of gaugings which was put in showed; and I may say, it showed this fact, that where a district is a very large district the sewage from the more distant parts requires a much longer time to get down to the point of outfall than from those which are nearer to it.

7675. (*Chairman.*) That is to say a longer proportion of time?—A longer time, because if there is a district 18 miles away from an outfall the sewage from that district will take a longer time than if it were a mile away.

7676. Would it take 18 times as long; that is to say a longer proportionate time?—A longer proportionate time.

7677. Would 18 times as long be all, or would it take a longer proportionate time, would it take 24 hours?—No.

7678. Would it take a time proportionate to its distance only?—I would point out with regard to this inequality in the flow of the sewage throughout the day, that there is one hour of the day when the quantity flowing is at the rate of three times what would be the mean flow: that hour in places in the metropolis which are close to the outfall would occur between 11 and 12 in the morning, and there is a slight rise as you come nearer meal times in the evening; and in the early hours of the morning in the district close to the outfall the lowest period of flow would be about three o'clock. Now, as these districts are more or less distant, it so happens that the maximum flow of the sewage from a district which is very remote may arrive at the outfall at the time of minimum flow from the district which is close by. Therefore it tends to equalise the flow during the day, and consequently you do not get that violent rate of fluctuation in the larger districts where you have a long system of sewerage. Taking the gaugings in the Mud Inquiry, I find it is equal to deferring the sewage of the south side 11 hours, that is to say, it takes the sewage of the most remote district 11 hours to get there while the sewage of other districts close to takes no great length of time: that brings the minimum period to 6 o'clock in the morning, and it brings the maximum flow to 6 in the evening. That is the reason of the difference. It is not that there is less sewage, for when you come to deal with the whole volume of the day there is no difference, but the distance equalizes the flow.

7679. (*Sir John Coode.*) That would be dependent upon the distance of the most distant part of the system from the outlet and upon the gradient?—That is so.

7680. You do not say that would affect the whole system equally?—I have been able to tabulate a statement which shows that fact. This is a Table which I have worked out for the metropolis, and the figures in this Table really show the per-centages, that is, they show the total volume of sewage flowing in gallons or feet in the day; if you multiply them by the decimal given and divide them by 100 the result will show the quantity of sewage flowing per minute at any hour in the day in the district.

*The table was handed in, and is as follows:*

The TOTAL QUANTITY of SEWAGE FLOWING per DAY multiplied by the following DECIMALS, and divided by 100, will give the QUANTITY FLOWING per MINUTE at any HOUR.

| | 1 A.M. | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 P.M. | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Run off at once - | ·0320 | ·0280 | ·0270 | ·0270 | ·0346 | ·0456 | ·0638 | ·0743 | ·0865 | ·1190 | ·1562 | ·1720 | ·1421 | ·1051 | ·0800 | ·0685 | ·0585 | ·0572 | ·0580 | ·0543 | ·0523 | ·0437 | ·0420 | ·0404 |
| Deferred 1 Hour - | ·0362 | ·0300 | ·0275 | ·0270 | ·0398 | ·0401 | ·0547 | ·0691 | ·0804 | ·1027 | ·1376 | ·1641 | ·1570 | ·1236 | ·0926 | ·0742 | ·0635 | ·0579 | ·0576 | ·0562 | ·0533 | ·0480 | ·0428 | ·0412 |
| „ 2 „ - | ·0381 | ·0335 | ·0290 | ·0273 | ·0295 | ·0357 | ·0480 | ·0612 | ·0749 | ·0933 | ·1206 | ·1491 | ·1568 | ·1397 | ·1091 | ·0845 | ·0690 | ·0614 | ·0579 | ·0565 | ·0549 | ·0501 | ·0460 | ·0420 |
| „ 3 „ - | ·0395 | ·0356 | ·0319 | ·0285 | ·0292 | ·0335 | ·0428 | ·0545 | ·0676 | ·0859 | ·1090 | ·1334 | ·1473 | ·1438 | ·1248 | ·0989 | ·0780 | ·0661 | ·0606 | ·0570 | ·0554 | ·0521 | ·0481 | ·0446 |
| „ 4 „ - | ·0421 | ·0372 | ·0339 | ·0309 | ·0297 | ·0324 | ·0396 | ·0491 | ·0610 | ·0778 | ·0999 | ·1216 | ·1352 | ·1389 | ·1311 | ·1135 | ·0908 | ·0739 | ·0644 | ·0593 | ·0561 | ·0531 | ·0501 | ·0465 |
| „ 5 „ - | ·0441 | ·0397 | ·0355 | ·0327 | ·0315 | ·0324 | ·0377 | ·0454 | ·0553 | ·0706 | ·0909 | ·1120 | ·1250 | ·1301 | ·1291 | ·1206 | ·1044 | ·0852 | ·0712 | ·0628 | ·0581 | ·0540 | ·0513 | ·0485 |
| „ 6 „ - | ·0461 | ·0418 | ·0379 | ·0343 | ·0330 | ·0335 | ·0369 | ·0429 | ·0513 | ·0644 | ·0829 | ·1025 | ·1163 | ·1222 | ·1230 | ·1204 | ·1118 | ·0976 | ·0813 | ·0688 | ·0612 | ·0560 | ·0523 | ·0497 |
| „ 7 „ - | ·0475 | ·0438 | ·0399 | ·0366 | ·0343 | ·0346 | ·0373 | ·0415 | ·0484 | ·0597 | ·0759 | ·0940 | ·1074 | ·1149 | ·1169 | ·1162 | ·1127 | ·1050 | ·0927 | ·0779 | ·0667 | ·0591 | ·0543 | ·0508 |
| „ 8 „ - | ·0487 | ·0453 | ·0420 | ·0385 | ·0363 | ·0356 | ·0378 | ·0414 | ·0465 | ·0562 | ·0704 | ·0867 | ·0993 | ·1072 | ·1110 | ·1115 | ·1098 | ·1065 | ·0997 | ·0884 | ·0751 | ·0642 | ·0572 | ·0528 |
| „ 9 „ - | ·0507 | ·0466 | ·0435 | ·0405 | ·0381 | ·0373 | ·0384 | ·0415 | ·0459 | ·0538 | ·0662 | ·0806 | ·0921 | ·0999 | ·1044 | ·1067 | ·1062 | ·1045 | ·1017 | ·0952 | ·0848 | ·0720 | ·0620 | ·0555 |
| „ 10 „ - | ·0534 | ·0486 | ·0448 | ·0420 | ·0399 | ·0388 | ·0397 | ·0417 | ·0456 | ·0526 | ·0631 | ·0758 | ·0862 | ·0933 | ·0981 | ·1012 | ·1023 | ·1017 | ·1003 | ·0973 | ·0915 | ·0810 | ·0692 | ·0600 |
| „ 11 „ - | ·0577 | ·0512 | ·0469 | ·0433 | ·0414 | ·0404 | ·0409 | ·0426 | ·0454 | ·0517 | ·0612 | ·0722 | ·0813 | ·0878 | ·0922 | ·0956 | ·0976 | ·0986 | ·0981 | ·0964 | ·0936 | ·0873 | ·0778 | ·0669 |
| „ 12 „ - | ·0642 | ·0554 | ·0494 | ·0453 | ·0427 | ·0417 | ·0422 | ·0435 | ·0459 | ·0511 | ·0597 | ·0697 | ·0775 | ·0832 | ·0872 | ·0904 | ·0928 | ·0945 | ·0955 | ·0947 | ·0930 | ·0898 | ·0838 | ·0749 |

*Note.*—The decimal to be used for the mean quantity per minute = ·0695.

*Mr. B. Latham, M. Inst. C.E.*

24 Jan. 1883.

7681. You do not lay that down as a rule applicable everywhere, do you?—That would apply all over the country to sewers where there is no leakage.

7682. (*Mr. Lumley Smith.*) It occurs to one immediately that during the whole time of the maximum flow of the sewage there would be less room in the sewers for the rainfall?—Yes, during the maximum flow there is less room for the rainfall.

7683. Have you calculated what rainfall there is room for when the maximum flow of the sewage is passing through the sewers?—I have taken the figures as given. I have a Table by means of which we show to what extent the sewage has been deferred, that is to say, how many hours it has been deferred from the most distant parts.

7684. In your judgment is that likely to cause the overflows to be brought more into requisition than had been estimated and provided for?—No; on the contrary it tends to equalize the flow; there is really more room in the sewers than had been calculated; that is to say, there is more room in the sewers during what would otherwise have been the maximum period.

7685. Practically it comes to this, that if all the sewage had had to come down in six hours they would have been running fuller than if it had to come down in nine hours?—That is so of course.

7686. Now with regard to the effect of this system upon the water having to be expelled through the storm overflows; have you anything to tell us as to that?—If the sewers are not large enough to take the sewage and the quantity of rain which they have been designed to take for a greater number of days or periods or times than was contemplated, then the overflows must act; and whatever brings those overflows into operation for a greater number of times must lead to a greater degree of pollution of the river in the higher parts, because it takes very much longer to get out the higher the sewage is put into the river.

7687. Looking at what we have got from Sir Joseph Bazalgette, and from the reports of the Board, as to the amount of sewage that actually goes out at Crossness and Barking, the sewage is there, I presume, composed partly of rainfall and partly of sewage proper?—Yes.

7688. Comparing Crossness and Barking what difference do you find in the composition?—I have analysed the quantities which have been put in by Sir Joseph Bazalgette, and have divided them into sewage proper and depth of rain flowing off the district. (*The following Table was handed in.*)

| Year. | Rainfall. | South of Thames. 40 square miles. Depth of Rain reported to flow off by Sewers at Crossness. | North of Thames. 54 square miles. Depth of Rain reported to flow off by Sewers at Barking. |
|---|---|---|---|
| | Inches. | Inches. | Inches. |
| 1875 | 29·28 | 18·3 | 0·4 |
| 1876 | 28·90 | 15·7 | 1·0 |
| 1877 | 29·26 | 21·4 | 3·6 |
| 1878 | 29·26 | 23·1 | 3·4 |
| 1879 | 30·23 | 28·9 | 7·4 |
| 1880 | 34·11 | 25·4 | 5·3 |
| 1881 | 24·30 | 20·8 | 5·3 |

I begin in the year 1875, as previously to that the Western sewage was pumped into the river at Cremorne, and this is the first year when it is was conveyed to both the outfalls—to Barking upon the north and Crossness upon the south. Here you will observe I have taken the area upon the south of the Thames at 40 square miles, and upon the north at 54. The way in which I arrived at these figures of depth of rain flowing off was by taking the actual figures which were given to us by Sir Joseph Bazalgette, and which are combined in another table, which I will now hand in. (*The same was handed in and was as follows.*)

| Years. | Crossness. Rainfall. | Population Registrar-General's District. | Total Quantity of Sewage per Annum. | Quantity of Sewage per Day. | Quantity of Sewage per Head per Day. |
|---|---|---|---|---|---|
| | | | Gallons. | Gallons. | Gallons. |
| 1875 - - | 29·28 | 1,084,439 | 23,505,775,239 | 64,399,384 | 59·4 |
| 1876 - - | 28·90 | 1,113,958 | 22,370,124,831 | 61,120,559 | 54·9 |
| 1877 - - | 29·26 | 1,144,282 | 26,008,009,706 | 71,254,821 | 62·2 |
| 1878 - - | 29·26 | 1,175,429 | 27,317,822,594 | 74,843,349 | 63·7 |
| 1879 - - | 30·23 | 1,207,427 | 31,065,965,556 | 85,112,234 | 70·5 |
| 1880 - - | 34·11 | 1,240,294 | 29,533,247,494 | 80,691,933 | 65·0 |
| 1881 - - | 24·30 | 1,274,058 | 27,223,090,538 | 74,583,809 | 58·5 |
| 1882 to Nov. 24th | — | 1,308,738 | 21,043,864,091 | 64,158,122 | 49·0 |

| Years. | Barking. Rainfall. | Population Registrar-General's District. | Total Quantity of Sewage per Annum. | Quantity of Sewage per Day. | Quantity of Sewage per Head per Day. |
|---|---|---|---|---|---|
| | | | Gallons. | Gallons. | Gallons. |
| 1875 - - | 29·28 | 2,394,986 | 26,955,262,659 | 73,850,034 | 30·8 |
| 1876 - - | 28·90 | 2,421,290 | 27,751,403,034 | 75,823,505 | 31·3 |
| 1877 - - | 29·26 | 2,447,882 | 29,995,714,676 | 82,180,040 | 33·6 |
| 1878 - - | 29·26 | 2,474,766 | 30,177,765,147 | 82,678,809 | 33·4 |
| 1879 - - | 30·23 | 2,501,946 | 33,616,848,827 | 92,100,955 | 36·8 |
| 1880 - - | 34·11 | 2,529,425 | 32,390,858,252 | 88,490,612 | 34·9 |
| 1881 - - | 24·30 | 2,557,205 | 32,632,794,334 | 89,404,916 | 34·9 |
| 1882 to Nov. 24th | — | 2,585,290 | 27,553,687,490 | 84,005,145 | 32·5 |

In the fourth columns are the actual figures given to us in gallons flowing off at Crossness and Barking; the fifth columns show the actual figures in gallons per day as having flowed into the river on the north and south.

7689. Your figures in the column headed, "Total "quantity of sewage per annum" you get from the figures given by the Metropolitan Board of Works?—Yes, that is the actual figure given to us.

7690. Then by division you get the amount per day?—By dividing that by 365 days and in leap years by 366 days, it gives us the number of gallons each day.

7691. Then how do you get the "Quantity of sewage per head per day"?—By dividing it by the population shown in the third column.

7692. How do you get the rainfall so as to separate the rainfall which flows off into the sewers from the sewage?—I have taken the water supply of the district in 1881 as shown to be supplied to the population.

7693. The actual water supply to the population appears from the returns of the water companies?—It does, they give us the quantity they supply on the south and on the north of the river.

7694. Is it fair to take the number of feet of water supplied by the companies as equal in sewage to the quantity that goes out at the outfalls?—Yes, that approximates pretty nearly to the five cubic feet per head which is the quantity given by the Metropolitan Board of Works.

7695. Then in order to calculate the quantity of sewage it is not necessary to calculate the solid matter?—No, it is not.

7696. By taking off the quantity of water supplied by the companies you get the quantity that goes off at the outfalls due to rain or other matter?—Yes, by deducting the actual quantity of water supplied that shows the balance, and by dividing that out we come

to the actual depth in inches which flows off the area, which is given at the head of the columns.

7697. (*Prof. Williamson.*) I do not understand the difference between the numbers under the heading "Quantity of sewage per head per day at Crossness" and those under the corresponding heading for Barking, how are they so different?—I cannot understand myself how there should be such an enormous difference, but they are the figures given to us.

7698. At Barking it is 5 cubic feet per head, but in the other case it is something like 8?—There is no doubt that on the south, out of the 50 gallons per head per day, there are 30 gallons of water supply and 20 gallons of leakage per day into the sewers.

7699. (*Chairman.*) What becomes of it?—It gets into the sewers from the subsoil and takes the place of sewage and rain, it becomes, as it were, an agricultural drain for draining the land.

7,700. You mean that the sewer drains more than is put into it?—It admits the water from the subsoil to a large extent.

7,701. (*Sir J. Coode.*) Practically one is double the other?—That is so. Those are the actual figures that are given to us, and we have given you every figure to show how we have arrived at it. If you diminish the population upon the south (which we say is incorrect) you must increase the volume per head, and if you diminish it upon the north you must increase the volume per head.

7,702. (*Mr. Lumley Smith.*) It comes to this, that although upon the south you have a smaller area, or rather a more thinly populated area?—Notwithstanding that we have a smaller area, and we have half of that area in which it was only contemplated to take one eighth of an inch instead of a quarter of an inch, yet we have the singular fact that the tables shew, in depth of rain, a relative ratio of 5, 6, and 7 times, and even in one case 40 times as much rain flowing off on the south side as on the north side.

7703. One word with regard to the thinness of the population. Is the principle of that this, that where you have a district which is thoroughly built over, all the rain falls on roof or pavement, and passes down the sewer; but where you have a district which is thinly populated all the water does not go into the sewers—is that the principle upon which the eighth is taken instead of the quarter?—I do not know, but it is a well-known meteorological fact that the higher the district the more rain falls on it, and, therefore, one would have thought it more necessary to make the larger provision for the higher district. Another reason may be that in a thinly populated district a smaller quantity of rain water would dilute the sewage to a given point, while in a thickly populated district it would require a larger amount of rainfall to dilute it to the same extent.

7704. But is it the fact that if you have a district completely built over all the water goes straight into the sewers?—Yes, certainly.

7705. But where you have a district which is partly houses and partly fields and gardens, then the same result does not follow?—In an agricultural district a very large proportion would go into the ordinary water-courses.

7706. Now the conclusion come to is this—that the amount of water, I prefer not to use the word "rainfall," or rather the amount of water and sewage which goes off at Crossness, is very much larger than the water which goes off at Barking?—Very much larger—as appears by the calculations.

7707. (*Chairman.*) Do you mean a larger absolute quantity?—A large quantity per square mile—larger in depth over the area. Your Lordship will see in the first column we give the actual rainfall, which is the average of the three gauges at Crossness. Then we give you the actual depth of rain flowing off upon the south, and the actual depth flowing off upon the north. In 1875 there are 29·28 inches of rain falling upon the south; 18·3 inches of that flowed off either by flowing into the sewers or by percolation into the sewers. Upon the north it was only four-tenths of an inch that actually flowed off. The difference between those figures, after deducting what had been really evaporated, must have come into the river at a higher point than the outfalls.

7708. Then it would seem that either the water, which ought to get out at Barking, is liberated by the storm overflows, or that the sewers which discharge at Crossness have been tapping underground springs?—It would seem to me that both causes operated.

7709. What is your reason for thinking that all the sewage which should go to Barking does not go there?—My reason for thinking so is because of these gaugings, which were taken some years ago at Crossness, and which were put in at length in the Mud Inquiry.

(*Chairman.*) What was that "Mud Inquiry;" was it as to whether there was any obstruction in the Thames?

(*Mr. Michael.*) It was as to whether banks of mud were formed by the sewage.

(*Mr. Lumley Smith.*) And formed an obstruction to the navigation.

(*Witness.*) This observation was taken in 1876 in very dry weather, when there was no rain at all.

7710. (*Mr. Lumley Smith.*) Taking a dry season would show that what has been discharged would not come from rain?—That would show that what had been discharged then could not possibly come from rain. The result of this showed that on the 12th July 1876, the quantity discharged in gallons at Crossness on this particular day was 52,256,223 gallons, and that was an excessively dry period; in fact the month of July was one of the smallest rainfalls that was ever recorded—there had been no rain from the 24th of June to the 6th of July. On that day, at 8 p.m., the sixteenth of an inch fell, and ·01 upon the 7th, and ·02 upon the 8th, and then upon the 12th these experiments commenced, and were conducted throughout the day. Then from the table of population in 1876 you will see that there is a little over 1,000,000 of population and 52,000,000 gallons of sewage, so that you have 50 gallons per head, that is 30 of sewage proper and 20 of leakage, as I have already stated.

7711. (*Chairman.*) When you say "sewage proper" you mean what was intended to go into the sewers?—And what is included as the water supply to the district, which is known.

7712. And then there was no storm overflow?—This was a time when there was absolutely no rain whatever. The last rain was upon the 8th of the month, and then upon the 12th this gauging began.

7713. Were there no streams at all flowing into the sewer in the sense in which the Fleet ditch now falls into the river?—There could be no surface streams. Everything was dried up that year in July—everything was as dry as it could possibly be. I was myself observing the river Graveney, and it was absolutely dry.

7714. There are some streams which run in the driest weather, such as the Wandle. There was not anything of that kind finding its way into the leakage you allege?—Not unless by leakage. There is the Ravensbourne, which has a run of a more or less permanent character, unless there was anything of that sort which emptied itself into the sewer it is difficult to account for it.

7715. The Ravensbourne does not empty itself into the sewer?—No, but there is a sewer running up the valley which might tap it somewhere.

7716. This would be material to our inquiry in this way, that it goes to show the incapacity of the sewer?—Yes; if you have 50 gallons instead of 30 gallons per head there must be a great number of days upon which there must be an overflow.

7717. It was something that was not calculated upon?—Quite so.

7718. And this is also of importance, not so much as to the great question of collection of sewage at the outlets, but as to the inefficiency of the sewers,

*Mr. B. Latham, M. Inst. C.E.*

24 Jan. 1883.

causing them to discharge into the river Thames from a long way up downwards?—That is so.

7719. (*Mr. Lumley Smith.*) I believe we can test this a little further. I believe the estimate made by the Board of the sewage proper is 31¼ gallons per head?—That is so; and that agrees very accurately indeed with the average between the north and south of the actual water supply in 1881.

7720. I will ask you what you have done for the purpose of testing that, and how you compare that with the actual water discharged at Crossness. I believe you took in 1881 the water supplied by the water companies at 149,190,703 gallons per day; is that correct?—That is right.

7721. Of which the north took 99,648,892 gallons, and the south took 49,541,811 gallons?—That is correct.

7722. Then the next thing is that you have the number of houses upon the north and upon the south?—Yes.

7723. What is the number of the north?—The number of houses to which the supply was distributed was, in the north, 396,350, and in the south 204,659.

7724. From that you would get the quantity of gallons of water supplied per house, what was that?—With regard to the quantity of gallons of water supplied per house, if we divide the actual quantity supplied by the number of houses in the north it shows that there are 251·4 gallons per house supplied, and upon the south, going through the same description of calculation, there are 230·8 gallons.

7725. Then you have to get the number of persons to each house?—Yes.

7726. How do you get that?—This applies to the whole of the district supplied by the water companies, which is a much larger district than the metropolis itself, and, therefore, we have to make this fit in for the metropolis. Therefore, we took the metropolis, and we found that, in the Census of 1881, upon the north there were 8·27 persons in a house, and that in the south there were 7·09 persons in a house; so that dividing the quantity of water supplied by the respective numbers in a house upon the north and south, we get this fact, that upon the north the volume of water supplied per head of the population was 30·4 gallons, and upon the south 32·5 gallons.

7727. That agrees pretty well with the Board's estimate?—It agrees very well indeed, if you take a mere arithmetical mean, with the estimate of five cubic feet, which the Metropolitan Board of Works engineer made some years ago for the quantity of sewage per head of the population.

7728. Then you have this, that upon the south you may take 32·5 gallons per head of the population per day?—Yes. In addition to this, there will be water from other sources, but there will also be loss of water. I will do the same as Sir Joseph Bazalgette did. He estimated this additional water at from 10,000,000 to 12,000,000 gallons per day, and he strikes off that quantity as against the loss from evaporation, and so on, of the water supply itself.

7729. That gives you the amount in gallons per head. Now upon the 12th of July 1876, which I think you mentioned as being a very dry period, what do you find going off at Crossness?—That the actual quantity is 52,256,223 gallons.

7730. Does that include sewage and rainfall?—It includes everything in the sewers then; it could not include rainfall, because it had been a very dry time; there had been no rain.

7731. You take that as including sewage only?—Yes, as including sewage only.

7732. What was the population at that time?—The population at that time in the Registrar General's district was 1,113,958.

7733. How many gallons per head do you find actually flowing out upon that occasion?—46·88 gallons estimated upon the entire population of the southern half of the metropolis; but if it were estimated upon the actual population, which is smaller, it would be probably 50 gallons per head.

7734. Then although the actual water supplied by the water companies is only 30 gallons a head you find going off at Crossness 46 gallons?—We find practically 50.

7735. (*Chairman.*) How are these sewers constructed? Are they not cemented?—I do not know. I have been in them once or twice, but I have not had an opportunity of ascertaining how they are constructed.

(*Chairman.*) Do you know whether that does not admit of this explanation, that the sewers practically drain the land through which they pass.

(*Witness.*) Of course it is not necessary that this should be leakage into the Metropolitan Board of Works sewer; it might be leakage into the local district sewers; but there is the fact.

7736. (*Mr. Lumley Smith to the Witness.*) The Table, I think, you have put in shows the relative amount of sewage per head of the population, north and south?—It does. You will observe that the last Table I have put in shows the relative amount of sewage up to the latest period that we have got, calculated at per head of population. It shows that the water supply upon the north would give you rather over 30 gallons per head, and that the sewage and rainfall combined upon the north has not been very much more than the actual water supply. In some years you will see, as in 1875, that the actual volume shown flowing off at Barking is even less than the estimated volume of sewage if you take it at 31¼ gallons per head.

7737. Will you point out in what column that appears?—In the last column of the Table you will see under the head of 1875 that the total volume flowing off is only 30·8 gallons per head per day.

7738. What are you going to compare that with?—With the actual volume of sewage, five cubic feet per head or 31¼ gallons.

7739. What you mean is that the amount that actually flowed off at Barking in 1875 was below what is found to be a correct estimate of the sewage per head?—That is so.

7740. And of rainfall at Barking that year there was none that flowed off?—Although there were 29 odd inches of rainfall that year, there was not any that flowed off at Barking.

7741. There was not any more water that flowed off at Barking than would have been due to the sewage itself?—There was rather less, if anything.

7742. If you are correct in asserting that the proper estimate for the sewage is 31¼ gallons, a quantity equal to the whole amount of the rainfall of that year would appear to have got into the Thames in some other way than by the sewers without passing through Barking?—Yes.

7743. And if it passed into the Thames at all it would have passed through the storm overflows higher up the river?—Yes, if this estimate is correct.

7744. Are these quantities found to be those actually flowing off?—Those are the actual figures given to us by Sir Joseph Bazalgette as the volume flowing off.

7745. Now what do you find to be the case in 1876?—The quantity per head is a shade more, but you will observe there that though there is a little less rainfall the quantity flowing away upon the north was rather more, though upon the south it was rather less.

7746. I understand from you that the last column shows the amount per head which actually flowed off, and you say you compare that with the 31¼ gallons which you take as the normal amount of what would be sewage; but would it not have been better to have had another column showing the amount of rain which did flow off somewhere?—But that is a most difficult thing to arrive at without actual gaugings because part of the rainfall evaporates.

7747. That is sufficient for us; that allows in 1875 nothing for rainfall and in 1876 a very small margin for rainfall: could not you tell us at all what margin

the other years allow for rainfall, perhaps you could calculate that?—It is not necessary to calculate that; you see at once, if you take the difference between 31¼ and what is actually shown as the "quantity of sewage "per head per day," what quantity goes as rain. I have shown in another table the actual depth flowing off, that gives the actual depth of rainfall itself separated from the sewage, there again you have an enormous difference in quantity.

7748. I may take it again that that Table shows us what went off at Barking and Crossness and what actually fell and must have gone into the river?—Part of the difference must have gone into the river.

7749. In your judgment would the sewage of the western area have affected the discharge in the north, and how would that affect the question?—As I mentioned yesterday, it is quite clear by reading through the Reports made by the Metropolitan Board of Works to Parliament that it was intended to treat the western district separately, and that after they had got out their plans and scheme for conveying the sewage of the rest of the metropolis to Barking, and after they had half constructed the northern outfall sewer, which was only calculated for a smaller area of the metropolis, they then proposed to take the Western sewage to Barking; and of course the consequence is that by this arrangement if the sewers are assumed to be conveying their normal quantity of sewage and rainfall (that is, the quantity which they stipulated in the original calculations) whenever the sewers are conveying that amount the whole of the sewage of the western district must be flowing out a higher point, as it cannot get to any point below the Abbey Mills. The northern outfall sewers are not large enough to take it.

7750. The Abbey Mills are the last pumping station, are they not, towards Barking?—They are under the word "Stratford" on the cartoon.

7751. I do not know whether you have spoken about the capacity of the sewers not being sufficient to take the quantity, have you the figures which show that?—I have the figures here; but perhaps I had better give you the data to show how I arrive at the Western District question. I find in Sir Joseph Bazalgette's Report of the 22nd of May 1856, at page 21, that if the Western District sewage is to be taken to Barking the reservoir must hold 9,000,000 cubic feet instead of 7,000,000 cubic feet. It has been reported to contain upon one occasion 39,000,000 gallons, which is equivalent to 6,240,000 cubic feet. That is in the Metropolitan Board's Report to Parliament of the 30th of July 1864. In the Thames Mud Inquiry, at Question 6894, and Question 7034 it is given at 35,000,000 gallons. In the Report made upon the 31st of December 1873 to Parliament, at page 72 it is stated that in order to make provision for the sewage of the western district the low level sewer had to be increased in size all the way to Abbey Mills beyond what it was originally proposed to be, and that was done; it was increased from 9 ft. to 10 ft. 3 in. diameter. And then it was necessary that "the capacity of the outfall sewer and "of the Barking reservoir should be similarly aug- "mented." This was not done as reported, for in Messrs. Bidder and Hawksley's Report of the 6th of April 1858, the section of the outfall sewer for dealing with a portion of the northern Metropolis shows that there were to be two nine feet by nine feet sewers from the high level and the middle level, having a fall of two feet per mile. It shows the three outfall sewers nine feet by nine feet, having a fall of two feet per mile. Then in the Metropolitan Board of Works' Report to Parliament of the 30th July 1859, at page 7, it is stated that the northern outfall is to consist of three nine feet by nine feet sewers, and that the western area is to drain to separate outfall works at Hammersmith Creek. In the Metropolitan Board of Works' Report to Parliament of the 9th of August 1861, at page 4, it was stated that the Northern Outfall Sewer had been let for 625,000*l.*, and that the amount of work executed up to June last was 39,000*l.* In the Metropolitan Board of Works' Report to Parliament of the 31st of July 1862 (this is after the outfall had been commenced) at page 2 it is stated that it had been proposed "to "form a covered reservoir and deodorise the sewage "of the western area at Fulham Fields near the "Kensington Canal, but in consequence of a nume- "rously signed memorial having been presented, "urging the Board not to adopt that course in conse- "quence of anticipated nuisance," the Board were carefully considering the matter. In the same Report at page 3, it is stated that the value of work executed in connection with the northern outfall up to the 30th of June was 320,000*l.*, so that rather more than half the contract work had been completed. Therefore at that time half the outfall was completed, and they were still considering the matter, whether the sewage of the western district was to go to Barking. In the Report of the 31st of July 1863, on page 5, it is stated that the Board had determined to carry the sewage of the western district to Barking. At this time it is stated on page 4 of the same Report, that 615,000*l.* worth of work had been executed. Of course, that resolution may have been arrived at immediately after the former Report, but at the same time it is quite clear from these Reports to Parliament that the northern outfall sewer was not contemplated to deal with the western area, and that after it was partly completed they proposed to take the western sewage there; and they did enlarge the low level sewer, as I have already said, but not the outfall sewers.

7752. The three outfall sewers all meet, do they not?—The high level, the middle level, and the low level meet at Abbey Mills, and there are some other branches which are shown upon the plan; they come there into the northern high level to the reservoir; that is the sewer to which I am referring; it consists of three nine feet by nine sewers, and those sewers are capable of discharging 33,000 cubic feet of sewage per minute; that is rather more than Sir Joseph Bazalgette put them at in the Thames Mud Inquiry: he took them at 32,700. Then the two nine feet sewers which come into it have a capacity of discharging 22,000 cubic feet per minute, and the ten feet three low level sewer of discharging 15,000 cubic feet per minute, so that we have the three sewers up to Abbey Mills capable of discharging 37,000 cubic feet per minute, while the three sewers below are only capable of discharging 33,000, showing a deficiency equal to 36,000,000 gallons a day.

7753. It is like the neck of a bottle; if the sewers are running full when they come to the pumping station at Stratford, there would be more in them than could be pumped into the outfall?—There would be more in them than the outfall could discharge, therefore it must overflow at a higher point.

7754. How often they do overflow you are not going into?—I am only dealing with the capacity of the sewers, and using the same formula for calculating their discharging capacity as was used in some of the early Metropolitan Board of Works' Reports.

7755. Have you the capacity of the discharge at the outfall at Barking?—The discharge at the outfall at Barking is 33,000 cubic feet a minute, while the sewers would bring down to Abbey Mills 37,000 cubic feet a minute.

7756. Upon the south have you corresponding figures?—Upon the south the sewer is capable of discharging 20,000 cubic feet a minute.

7757. And the outfall?—There is but one sewer there. I have dealt with this separately in this way, that if we take the ordinary sewage which is shown by the gaugings to be upon the south eight cubic feet per head of the population, during the nine hours of maximum flow instead of six, we have got 8,955·5 cubic feet per minute of sewage, to which if we add a quarter of an inch of rain flowing off 20 miles, and one-eighth of an inch flowing off another 20 miles, they equal together 12,075 cubic feet, and the rain and sewage together are equal to 21,660·5 cubic feet; so that as the sewer is only capable of discharging 20,000 cubic feet there is a deficiency there of about

*Mr. B. Latham, M. Inst. C.E.*

24 Jan. 1883.

15,000,000 gallons a day. We have got these figures more accurately for the south having got the gaugings for one day for the south and none for the north, but I have taken the northern outfall, and if you take the figures which have been given to us of the volume of rainfall as 28,500,000 cubic feet per day (the quantity stated in the Report of Messrs. Bidder, Hawksley, and Bazalgette, and also as stated in the Report to Parliament) that is equal to 19,791·7 cubic feet per minute. Now, if you take the estimate of the Metropolitan Board of Works' engineer of five cubic feet per head of sewage, half flowing off in six hours, from 2,353,900 persons (their estimate of the population at the time) it gives 16,346·5 cubic feet per minute; and those two figures added together are equal to 36,138 cubic feet a minute; showing that according to their own population this northern outfall sewer never could have carried the quantity for which it was designed.

7758. (*Professor Williamson.*) Are you taking half the five cubic feet as being discharged in all places simultaneously in six hours, or do you make allowance for the difference of distance that the quantity would have to travel?—No; upon the north we know nothing about the figures. Upon the south I am able to tell when it flows off. But as regards the sewers, on the north, taking their own figures of the volume of rain as admitted, and the volume of sewage from the population as that which they give, it shows that they never could have been adequate to the maximum by the difference between 33,000 cubic feet and 36,158 cubic feet. But if we add to that the population which we know exists outside and the rainfall from the outside, a very much larger deficiency arises. You will see that in the case of the outside district, whatever rain falls must go into the sewers, and must first occupy them, as they occupy the highest position, to the exclusion of any other water which comes into the Metropolis; for until part of that can flow away by the storm overflow it must still occupy the sewer to the exclusion of whatever comes in from the Metropolis itself.

7759. (*Chairman.*) The sewers will carry off the sewage without rain water, they are sufficient for that?—Yes, they are sufficient for that.

7760. It was contemplated that there would be sometimes storms of such excess that they would not carry the water off?—Yes, it was contemplated that might happen.

7761. But in certain rainfalls they would?—Yes.

7762. Can you tell us what proportion or quantity of rainfall they calculated they could carry off so as to show us how many days there would be an overflowing of storm water?—They have already shown us that if the rain happened to come when there was the maximum period of flow they would only carry away one-hundredth of an inch per hour.

7763. But does it at all appear upon how many days they calculated that there would be a greater flow than that?—The evidence which they give in this report would lead you to believe that it only occurred upon 12½ days, for they say that although the sewers will carry a quarter of an inch that quarter of an inch is produced by four-tenths of an inch of rainfall, and they state that that rainfall only occurs upon 12½ days of the year. But that is an entirely erroneous assumption, because you have to do with the rate at which the rain falls, and not with the quantity falling in the day. I have had observations taken at Croydon by means of a registering and recording rain gauge, by which every drop of rain which falls, and the rate at which it falls, is recorded; and I have an apparatus showing to what extent the sewers are affected by these rainfalls, but at Croydon the conditions are more favourable, and the sewers do not show such great fluctuations in flow as in London, for this reason, that a large portion of the surface water is not admitted into the sewers, it is only that portion falling upon the roofs of the houses that we deal with. But I shall be able to show you from these observations which I have made that it seldom rains, but the sewers must be affected to a greater extent than for which provision is made.

7764. (*Mr. Lumley Smith.*) I think you have a reference to one report of Sir Joseph Bazalgette upon the subject in 1853?—Yes, I find that Sir Joseph Bazalgette, when the great London Drainage Bill was before Parliament, made a report and gave evidence upon the question. I find that that Company proposed to admit a quarter of an inch of rainfall, whereupon he gave evidence to the effect that if they admitted no more rainfall than that the sewers must still overflow into the river all the way along, on from 80 to 100 days in the year.

7765. (*Chairman.*) Did Sir Joseph Bazalgette say so?—Yes; I will find you the reference to it. I have here the evidence which was given before the Select Committee of the House of Commons upon the great London Drainage Bill, on the 10th of June 1853, and you will observe the passage of Sir Joseph Bazalgette's evidence, which is within pencil marks — it is at Question No. 2558.

*The passage referred to was as follows:—*

"*Q.* Assume that a hundredth part of an inch of "rain per hour falls in addition to the maximum flow "of sewage passing into the sewers what would that "give?—*A.* For 47½ square miles it would give "19,132 cubic feet per minute, which added to "12,638 cubic feet of sewage, would give 31,770 "cubic feet per minute. The quantity that the sewer "would carry off may be taken at what the pro-"moters' engineers put it at. The sewer would be "too small for that quantity; I do not say that that "is the quantity to be carried off, it is a question of "degree. Thus, the more you can carry off the less "frequently will the sewage go into the river; the "less you carry off the more frequently. I think if "it were capable of carrying off that quantity, still "from 80 to 100 days the sewage mixing with the "rainfall would go into the river. The average of "the last four years give 150 days per annum on "which rain falls."

Adjourned to Tuesday next at half-past twelve.

# SEVENTEENTH DAY.

## Tuesday, 30th January 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR P. BENSON MAXWELL.
SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
WILLIAM POLE, Esq., F.R.S., *Secretary*.

30 Jan. 1883.

(*Mr. Lumley Smith.*) Will you allow me to observe before going on with the evidence that there was handed in upon the last occasion a series of tables which had been prepared by Mr. Mansergh, whom I am going to call, which showed the effect of the mixing action upon the river Thames. It showed the various points along the river from Teddington to Southend, the actual area of the cross section and the relative portions occupied by sea water, and water that was otherwise than sea water; and, upon those calculations which had been prepared by Mr. Mansergh, Mr. Latham had formed certain calculations, and Mr. Mansergh, with the view to his examination, has been engaged in checking the areas derived from the cross sections, and he finds that with regard to one cross section there has been an error of calculation; that a figure has slipped out,—a figure which was 242 was carried out as 42,—the result is that there ought to be an addition to the sectional area at Crossness of 6,400 feet. In consequence of that I have had amended tables prepared, and the figures which are affected are the figures upon the line at Crossness. Those amended figures will have to be given.

(*Chairman.*) That removes a difficulty that I pointed out, does it not?

(*Mr. Lumley Smith.*) It does remove the difficulty of there being apparently less sewage at low water at Crossness than there was at Barking, although there was, as my learned friend pointed out, an additional outfall. But it still appears that at high water at Crossness there is very little less sewage in the water than at Barking, but that probably will be owing to the high water having pushed up the more diluted water from the sea.

MR. BALDWIN LATHAM, Mem. Inst. C.E., called in, and further examined.

*Mr. B. Latham, M. Inst. C.E.*

7766. (*Mr. Lumley Smith.*) We left off upon the last occasion when some questions had been asked by my Lord as to the number of days on which the rainfall would probably exceed the amount originally provided for; I think you gave us the passage from Sir Joseph Bazalgette's evidence which now is printed upon the notes of the last day's evidence, which shows that on from 80 to 100 days the sewage mixing with the rainfall would go into the river?—That is so.

7767. Have you referred to any other extracts from reports which bear at all upon that subject, which you could conveniently give us?—There are other passages in the same evidence.

7768. If there are any other passages to which you think it is important that attention should be drawn, perhaps you will mention them?—Question 2536 in the evidence given upon the London Drainage Bill on the 10th of June 1853 was, "For how many "days, as you compute, would the sewage continue "to flow into the Thames as at present?" And the answer was, "I think that something near 100 days "in a year the sewage would continue to flow into "the Thames." Then there is a report of the 7th of May 1853 to the Commissioners of Sewers by Sir Joseph Bazalgette and Colonel Hayward to this effect, "There must still be from 80 to 100 days when a por- "tion of the sewage mixed with the rainfall must in "quantities more or less go into the river as at "present." And to show that this London drainage scheme contemplated taking a quarter of an inch into the sewers, the engineer for the scheme, Mr. Mitchell, at question 520 refers to the quarter of an inch of rainfall, and states that it does not occur on more than 23 or 24 days in the year; that was the quantity which they proposed to admit into the sewers. Then at 521, he was asked, "You provide for all but those "23 or 24 days upon which more than a quarter of "an inch falls," and his answer was, "Yes."

7769. Those are all passages from the evidence given upon the same inquiry?—Upon the same inquiry.

7770. That is to say, given before the Select Committee of the House of Commons on the London Drainage Bill, on the 10th of June 1853?—The last one I quoted was from the evidence given upon the 6th of June 1853.

7771. Are there any other passages to which you wish to draw attention before I pass on?—Not with regard to the quarter of an inch.

7772. I believe you yourself have, for a considerable period, been conducting experiments at Croydon with regard to the rainfall?—Yes.

7773. And as to the way in which that affects the sewers?—Yes.

7774. (*Chairman.*) I should like to ask this question—the statement quoted from Sir Joseph Bazalgette's evidence is, "Still, from 80 to 100 days the "sewage mixing with the rainfall would go into the "river;" that does not, of course, mean the whole of it?—No.

7775. It might be 5 per cent. of the mixture of rainfall and sewage?—It all depends upon the rate at which the rain has been falling. The sewers were calculated or supposed to take 100th of an inch of rain an hour. But your Lordship will observe, from what I have already stated, that in the higher parts of the district the sewers were not calculated to take 100th of an inch an hour, but only half of it; so that whenever it rained at such a rate that the water would enter the sewers at a greater rate than the 100th of an inch an hour, and at the same time there was the maximum flow of sewage passing, that would cause the sewers to overflow.

7776. I am not saying that 100th of an inch might not be an objectionable thing, but it might not be more than one per cent. of the volume of sewage?—The overflow might not exceed that, or it might exceed it many times.

(*Chairman.*) All I mean is that this quotation from the evidence is very vague and uncertain, as you cannot tell what quantity would go.

(*Mr. Lumley Smith.*) It cannot, of course, be more than a matter of general supposition.

7777. (*Chairman.*) Suppose the 100th of an inch in an hour, and the sewage at its maximum rate, can you tell what percentage of what we may call the mixture would overflow?—I think I have already given the figures to show what the 100th of an inch

*Mr. B. Latham, M. Inst. C.E.*

30 Jan. 1883.

produces in an hour, and what the ordinary sewage is, showing that the rainfall is very much in excess of the sewage itself.

7778. We have it that "for 47½ square miles it "would give 19,132 cubic feet per minute, which, "added to 12,638 cubic feet of sewage, would give "31,770 cubic feet per minute. The quantity that "the sewer would carry off may be taken at what the "promoters' engineers put it at;" what is it that these sewers would carry off?—That I have not worked out. What was then proposed was a different fall altogether from that of any of the present sewers.

(*Mr. Lumley Smith.*) Your Lordship sees that many of the storm overflows are self-acting, and that what passes through them in the course of a storm is not measured; so that it is only by calculations or estimates of this kind that you can get any idea of what quantity does go into the river other than through Crossness and Barking.

(*Chairman.*) Say, sewage 12 and rainfall 19, making 31; if the capacity of the sewer were 32, about 3 per cent. of the total quantity would be overflow, and of that 3 per cent. nearly 2 per cent. would be rainwater and 1 per cent. would be sewage. I do not mean to say that that would not be a serious amount, but it would be diluted.

(*Mr. Lumley Smith.*) No doubt.

(*Mr. Bidder.*) Your Lordship sees that what another gentleman says would be the consequence of the adoption of another scheme, which never was adopted, is very remote from the question before you.

(*Chairman.*) I understand Mr. Latham to say that what Sir Joseph Bazalgette said he said truly.

(*Mr. Bidder.*) But what Sir Joseph Bazalgette said upon that occasion was with regard to a certain Bill then before Parliament, which was of a radically different character from anything that now exists, and it is rather a hasty assumption to assume against Sir Joseph Bazalgette that, because he said certain consequences would arise if certain works were carried out, therefore he inferred that the same consequences would arise if entirely different works were carried out. The quantity of overflow depended upon the capacity of the streams to carry off the quantity of water; the quantities or capacities of the two streams are enormously different.

(*Chairman.*) You surmise that the sewers are of a greater capacity than the suggested sewers which this evidence referred to.

(*Mr. Bidder.*) About two and a half times as great.

(*Chairman.*) If that is so, that makes the evidence not of much value certainly.

(*Witness.*) I am afraid that is not so; there is evidence given before the Committee as to the discharging capacity of the proposed sewers, and you will observe that the area drained is very much smaller than that now actually drained in the Metropolis; but I would draw attention to this fact in this former evidence that this is a quarter of an inch of rainfall proposed to be admitted in addition to the ordinary sewage, and it is exactly the same amount as is now stated to be admitted, but in fact was really more; because in some parts at the present time an eighth of an inch is admitted, and it was pointed out that in that time the overflow would be from 80 to 100 days with a quarter of an inch, whereas now the overflow is put at from 14 to 30 days with less than a quarter of an inch.

7779. (*Chairman.*) Mr. Bidder's objection is this; he said Sir Joseph Bazalgette took this to be true, and no doubt it was true, but how is that relevant when the sewers in actual existence are two and a half times the carrying and discharging capacity of the sewers of which he was speaking. Do you agree that the sewers now are of a greater capacity than the contemplated sewers they were speaking of?—No, I do not. I think I can find out what the discharging capacity of these sewers was proposed to be, they proposed to deal with a hypothetical future population just as the present sewers did; and yet it is said, with regard to the existing sewers, that they can only overflow from 14 to 30 days, whereas of the former sewers it was said that they would overflow from 80 to 100 days.

(*Chairman.*) Have the present sewers a greater carrying and discharging capacity than the sewers then contemplated?

(*Witness.*) Not with regard to the area.

(*Mr. Lumley Smith.*) Having regard to the area and the population, do you think there are such distinctions between the scheme then proposed and the scheme now in use as to make that calculation erroneous?

(*Mr. Bidder.*) I may help you in answering that question. I am told that the sewerage scheme upon the north side of the Thames proposed one sewer 10 feet 3 inches diameter, whereas the existing scheme contains three sewers of 9 feet diameter each.

(*Witness.*) But you must bear this in mind that the sewers are just four feet a mile fall, instead of two feet a mile fall, whatever their size was.

(*Mr. Lumley Smith.*) I do not know whether you have gone sufficiently into the details of that scheme to be able to compare the respective areas drained, and the two populations.

(*Chairman.*) I suppose the witness will admit that the discharging capacity of the actual sewer is very much greater than that of the sewer then contemplated.

(*Mr. Bidder.*) Very much greater.

(*Witness.*) The answer to question 538 of the engineer's evidence of the 6th of June 1853 shows that the discharging capacity of the sewer was 20,000 feet a minute.

7780. (*Chairman.*) And what do you say is the discharging capacity of the existing ones?—The discharging capacity of the three existing ones is 33,000 cubic feet a minute.

7781. (*Mr. Bidder.*) Do you mean upon the north side?—Yes.

(*Mr. Bidder.*) I will give you what Sir Joseph Bazalgette gives to me. The discharging capacity of Mr. Mitchell's north side 19,000, and of the existing north side 33,000; south side discharging capacity, Mr. Mitchell 5,300, and the capacity of the sewer as now constructed 19,000, making the two sides together 24,000 as proposed, and 52,000 as constructed; therefore, I was speaking roundly of the two together; I ought to have said, if you take them separately, north side not quite double, and south side rather more than three times.

7782. (*Chairman.*) I think we must take each side separately. I do not know whether you will agree to those figures of 19,000 and 33,000?—I have already given the discharging capacity of the northern outfall as 33,000, as against 32,700 given by Sir Joseph Bazalgette the Mud Inquiry.

7783. Do you agree that this former proposition gave a discharging capacity of 19,000?—No, it gave 20,000; and, moreover, it was only dealing with the low level district and the low level sewer; and it was afterwards stated in evidence that when the population increased a high level sewer would be put in.

(*Mr. Bidder.*) But Mr. Mitchell stated that he was going to deal with 47 miles upon the north side.

(*Chairman.*) This is a matter upon which there can be no real difference between Sir Joseph Bazalgette and the witness, because it seems to be a matter of abstract calculation.

7784. (*Mr. Lumley Smith to the witness.*) You proceeded upon the same plan as Sir Joseph Bazalgette, I think, by taking the average rain of the day at per hour?—Yes.

7785. And you have also adopted the same plan of taking the discharge from the number of square miles?—Yes; I read the passage upon the last occasion, showing that it was 47½ miles; but it was stated in the Metropolitan Board of Works Report that the drainage area is 59 miles at the present time.

7786. (*Chairman.*) Taking the carrying and discharging capacity of the sewers to be what they now are, what would be the number of days upon which

there would be an overflow according to your calculation?—I am going to give you that from direct observations.

7787. (*Mr. Lumley Smith.*) Will you tell us the number of observations which you have made upon which you base your resulting opinion?—For some years I have thought it very important that engineers should know more about the rate at which rain falls, and I have designed a registering rain-gauge, which has now been at work at my house at Croydon since the beginning of 1879. That records the time of day, the quantity and the rate at which rain falls. Then, while I was making these observations, I was gauging the Croydon sewers, not to see the quantity of the rain or how that affected them, but simply because there was a leakage into the Croydon sewers of spring water. I was desirous of ascertaining what was the quantity of the leakage, as the object of my experiments was to ascertain the amount of water which the chalk formation in that neighbourhood yielded; but in making those experiments I have been obliged to deduct every day the quantity of sewage proper; and, knowing also the rate of fluctuation at every moment of the day, I am able to show how much any particular fall of rain affects the fluctuation in the Croydon sewers. But I should say that with regard to Croydon it will not compare with London, for this reason, that a very large amount of the rainfall at Croydon is excluded from the sewers; that is, that there is a separate system for taking the rain from the streets, and it is only the rain from the roofs of the houses which could not be excluded from the sewers, and that which finds its way into the sewers. In districts where the rainfall from the whole district is admitted into the sewers it would cause a very much greater rate of fluctuation. At Croydon the way in which it has been done is by affixing upon the outfall sewer a recording machine which is actuated by a float. These are the diagrams (*shewing some diagrams*) which show the quantity in cube feet per minute every hour of the day, and I have here a continuous record of the total quantity at every hour of the day, and the average and the actual quantity of the sewage flowing every day (*producing the same, see Appendix* A. C.)

7788. (*Mr. Bidder.*) Will you just explain how that bears upon this inquiry?—I am just pointing out in a district like this the mode in which the observations have been made, so as to show how much rain in this particular district affects the sewers at the particular period when the rain occurs.

(*Chairman.*) Could you tell us what the result of your experiments was?

7789. (*Mr. Lumley Smith.*) As I understand, you had an opportunity of gauging the quantity of sewage that passed out at Croydon?—Yes.

7790. And you also had an opportunity of accurately gauging the amount of rain that fell?—Yes.

7791. And you were enabled to compare those observations, and so far form an opinion how far the rainfall affects the discharge from the sewers?—Yes.

7792. In comparing Croydon and London, are there certain corrections to be made, because in Croydon there is more rainfall diverted from the sewers than in London?—That is so.

7793. Bearing in mind these distinctions, will you tell us the conclusion you come to with regard to the sewers?—I must also make another observation with regard to the rainfall and the sewers, and that is, that the degree of fluctuation caused by rain depends upon the time of day when the rain falls. If it should happen that the rain occurs when the minimum quantity of sewage is flowing through the sewer, it will not affect the mean quantity to the same extent as it would if it occurred at the period when the maximum quantity was flowing through the sewer.

7794. (*Sir John Coode.*) When you say it will not affect the mean, you mean it will not affect the gorging or the overflow?—I am going to show the ratio of increase in the sewers by particular rains. At some periods you would get a very small increase beyond the normal flow; at other times you would get it considerably greater, owing to the fluctuation of the sewage itself; but by taking a very large number of observations, extending over a number of years, you may expect to arrive at a reasonably fair conclusion. In this case I have 573 distinct observations, every one of them made on a separate day, and every one of them made within a certain single hour, and they show that during that period there were 152 days in the average of the last three years and nine months when rain at the rate recorded in those tables fell; that is to say, there were 152 days in a year on the average on which ·065 of an inch fell in an hour. That is the average of the single hour carried over the 573 days, and showing the rate at which rain fell.

7795. (*Mr. Bidder.*) Irrespective of the duration of the time during which rain fell at that rate?—I have here the times at which it fell. I have the quantity which fell in the day, and the quantity in the hour, the time in which that fell, the rate of fall in 24 hours, and the time of day at which it fell, and the proportion of the flow of sewage to the mean fall caused by the particular rainfall.

7796. Will you tell us on how many days the quarter of an inch fell?—I have already pointed out that there were 152 days in a year upon which an average of $\frac{6}{100}$ths of an inch fell in the hour.

7797. (*Mr. Lumley Smith.*) We have to consider, have we not, whether that all fell in a few minutes or in an hour?—Yes.

7798. Does your table show the duration of time in which that fell?—It does.

7799. (*Chairman.*) So far as it relates to the actual fall of rain, would Croydon be a fair parallel to London?—There would be little or no difference.

7800. (*Mr. Bidder.*) Subject to one very important observation, that in Croydon you are dealing with the observation of a particular spot, and discussing the area these sewers have got to do with as compared with an area of over 100 miles, you cannot argue from what you get at a particular spot to what you get over 100 square miles.

(*Chairman.*) Not if you take 573 observations?

(*Mr. Bidder.*) No, because we are dealing with what may be called sharp showers, which are, as we know, very local.

(*Chairman.*) But the extraordinary falls are no more likely to happen in Croydon than at any other place.

(*Mr. Bidder.*) No, I agree to that. But the question is whether the main intercepting sewers can deal with a similar rainfall in a certain time over any part of the whole area of the Metropolis. Assuming that these observations represent not only the number of showers you might expect at Croydon, but at any particular spot of the Metropolis, you must not infer that you would get that number of showers of that violence over the whole of the Metropolis. It may be perfectly fine at Norwood, for example, but there may be a smart shower at Hampstead.

(*Chairman.*) The witness gives you the benefit of that by taking a fine day at Croydon when it may have been fine at Hampstead.

(*Mr. Bidder.*) No, the witness says there is a fine day at Hampstead when at Croydon rain falls which would overtask the sewers; now assume that as a fair sample of what happens in the Metropolis; then, if you had your rain gauge at Hampstead or anywhere else, you would get that same result; but when you are discussing whether upon 152 days you will have that quantity of rain falling over part of the area, you must bear in mind that the 152 showers at Croydon will not happen at the same time as 152 showers at Westminster, for example.

(*Chairman.*) Let us see how you address yourself to Mr. Bidder's objection.

(*Sir John Coode.*) I thought Mr. Bidder's argument was that, although you may have that particular rainfall at a particular spot at Croydon, you will not find a rainfall to the same extent over the area drained by the Metropolitan system.

*Mr. B. Latham, M. Inst. C.E.*

30 Jan. 1883.

(*Mr. Bidder.*) That is so.

(*Mr. Lumley Smith.*) Then the deduction that the witness draws is this, that, as this particular fall at Hampstead may be carried away by all the sewers in the Metropolis, they being united and able to take it off, yet in reality the overflow goes into the sewers at that particular point.

(*Mr. Bidder.*) Suppose there was a smart thundershower at Hampstead which was so much beyond the capacity of the Hampstead sewers that it ran down the gutters of the roads; before it can get to the Thames it must have overtasked the intercepting main sewer.

(*Mr. Michael.*) Three of them.

(*Witness.*) I can only tell you this, that I have a very much larger area under investigation for rainfall than the Metropolis. I have rain gauges all through the county of Surrey, and it is very rarely, when the rain does occur, that it does not occur generally throughout the district. There are of course exceptions, but principally in summer time, and those are the times when there are certainly local thunderstorms.

7801. (*Mr. Lumley Smith.*) Do your observations distinguish at all between what are local thunderstorms and what are merely increased quantities of rain falling on rainy days?—We could show, because we mark them, what is due to thunderstorms, but we have not had so many thunderstorms of recent years as occurred formerly.

7802. But the result, as you told us, is this, that the number of days upon which a given quantity of rain falls in an hour exceeds that which was calculated for in the metropolitan drainage scheme?—Yes. Now I was going to explain that in the nine months of 1879 (taking the average of all the observations upon the days upon which rain fell) there were 133 days upon which rain fell, and the average of all those in one hour was ·066; and I find that on the average that increased the mean flow in the Croydon sewer by 4·9 times. In 1880 there were 135 days in the whole year when rain fell at the rate, upon the average of one hour, of ·075. Now that was the driest year with regard to the number of days, and yet it had the greatest rate of rain; the rainfall was 30 inches in that year, as recorded at the site where the registering rain gauge was located. That increased the flow in the sewers 3·78 times; it was a much drier year on the whole, for 1879 was a notoriously wet year.

7803. (*Chairman.*) You say it increases the flow by 3·78 times?—Yes, its mean flow.

7804. That is during the time the rain was lasting?—If you refer to the particular hour, which is shown in the column at which that particular rain affected the sewers, you will find that on an average of all the experiments, the increase was 3·78 times the mean flow in the sewers.

7805. That made it about four times as much as it was before?—Yes, that is so.

7806. Was the rain that fell four times the quantity of the sewage?—It may have been more than that.

7807. But according to your gauge?—If it continued at that rate during the whole 24 hours, it would have been.

7808. Then we do not understand that it continued at the same rate all the 24 hours?—No, only during that hour.

7809. (*Mr. Bidder.*) Then comes the question, How far is the Croydon sewage neat sewage as compared with London sewage, which is very diluted. But the Croydon sewage, as I understand, is very much less adulterated with water?—It is quite the reverse; the quantity of water supplied at Croydon is 50 gallons a head, and therefore the quantity of sewage is much greater per head of the population.

7810. (*Chairman.*) But you said a good deal of the storm water ran away and was not mixed with the sewage?—Part of the rain water itself is not carried into the sewers, being carried into a separate system, but still this is the result with this separate system, showing with these separate systems how the quantity that gets in affects the mean flow. There is more sewage per head of the population in dry weather in Croydon than there is upon the north side of London. Upon the south side, as I have already pointed out, it is about the same as at Croydon, but in addition to that there is a large amount of leakage into the Croydon sewers, which greatly increases it again; and it was my object in making these observations to ascertain the extent of that leakage. Then, in 1881, there were 144 days when the falls were observed, and the average of those was ·06 per hour, and the increase in the flow of the sewers of that year was 4·27 times the mean flow. In 1882 there were 161 days when the falls were observed to affect the sewers, and the average rate of fall in all those days was ·06, and the increase of the sewers during that period was 3·7 times the mean flow. There is no doubt that, owing to the leaky character of the sewers at Croydon, when rain does fall, some of it does run out into the subsoil, as during the dry years of 1880 and 1882; that is to say, we have had lower springs in those two years than we have had at other periods; we do not get all the rain that gets in measured, because the leaky sewers act as overflows. The average shows that of all those periods of the 573 observations upon the sewers the mean rate of flow is increased 4·16 times.

7811. (*Mr. Lumley Smith.*) By what quantity of rain?—By ·065.

7812. (*Chairman.*) Are the sewers capable of carrying off that quantity at Croydon?—Yes, there are no overflows whatever except those by percolation into the ground.

7813. Then is the inference that, if the London sewage had been increased at the same rate, there would have been an overflow?—There must have been an overflow all this time; but, the London sewers admitting more rainfall than we do, the ratio must have been greater.

7814. Is it the fact that in London the sewers admit a larger proportion of the rainfall than at Croydon?—Certainly, in London the sewers admit all the rainfall, whereas at Croydon they only admit that which falls upon the roofs of the houses.

7815. (*Chairman.*) Is it the fact that at Croydon the sewers would carry off five or six times the volume of sewage which they habitually have?—They would carry more than that. There are times that the rainfall has exceeded 12 times the mean flow, and they have carried it off; and I have made observations upon days upon which a quarter of an inch and less has fallen, which shows the enormous ratio which takes place sometimes. For example, upon the 20th April 1879, a quarter of an inch of rain fell in 24 hours. In one hour of that day the rain caused the flow in the sewer to fluctuate in the ratio of 7·1 times its mean flow. Then again, upon the 25th of June, when there was only ·135 of rain, that caused an increase of seven times the mean flow in the sewers. Then again, upon the 13th of September with a quarter of an inch of rainfall, there was an increase in the mean flow of 6·3 times. In 1880 there was not such a great rate of fluctuation, but upon the 8th February, with ·14 of an inch of rain, the ratio was 5·2.

7816. (*Chairman.*) Let me ask you a question to see if I understand this. Of course you know the volume of the discharge of the sewage?—Yes.

7817. You calculate the area over which the rain fell. You can calculate it in a sense, but not altogether, as you cannot make an accurate deduction for roads and gardens?—It is almost impossible. The total drainage area draining to these sewers is about 1,990 acres, but how much of that has rain falling off it, it is almost impossible to tell with any degree of accuracy. Then I was going to show that in 1881 upon the 6th of July ·16 of an inch fell in 24 hours, which increased the flow in the sewers by 7·2 times the mean flow; and upon the 2nd of October of this year, when ·21 of an inch fell in the day, it increased the flow in the sewers 8·3 times the mean flow. I have a large number of observations which show that there are occasions when a very much smaller quantity

than a quarter of an inch of rain in 24 hours increases the mean flow in the sewers eight times.

7818. (*Sir John Coode.*) Have you made any observations to show how often in the year the Metropolitan sewers overflow into the Thames?—I have no information upon that point.

(*Mr. Bidder.*) We shall be able to give the Commission at the proper time some actual facts, at any rate, as to one of the principal ones.

7819. (*Chairman to the witness.*) Your evidence will go to show how many times they ought to overflow, so to speak?—My evidence is to show that, with the certain rates at which rain falls, and the certain rates at which it flows off, as shown by the fluctuations of the sewer at Croydon, under any circumstances any set of sewers must be affected in some degree by these conditions.

7820. You invite the inference that the augmentation of what went through the sewers in London would be the same as you have found in Croydon?—At least.

7821. And that therefore it ought to or would overflow on so many occasions; but I suppose they know upon the side of the Metropolitan Board of Works what the actual number was, do they not?——

(*Mr. Bidder.*) I know in one of the principal cases that it is a very different number from what the witness has suggested.

(*Mr. Lumley Smith.*) In the general sketch that was given by Sir Joseph Bazalgette at the beginning of this inquiry he gave it as a matter of estimate that probably upon some 14 days in the year there would be an overflow.

(*Sir John Coode.*) Sir Joseph Bazalgette said from 14 to 21 days, and in a very wet season he said 30 days.

(*Mr. Bidder.*) In many cases it is practically impossible to have observations, but in one case, if not more, we have the actual records and shall be able to give you the facts extending over several years. I shall be able to give you the facts extending over seven or eight years, but I cannot pretend that I shall be able to give them to you extending over all the outfalls.

(*Sir John Coode.*) About what proportion of the whole number shall you be able to give evidence?

(*Mr. Bidder.*) I can hardly tell you at present. Probably it has occurred to the Commissioners that, before inferring from Croydon, or from any place to London, there are ever so many elements to be taken into consideration, not merely the rainfall; because, for instance, the amount by which the volume in the sewer is increased by a certain rainfall depends upon the relative proportion of the area contributing rain to the sewer to the population whose sewage is in the sewer.

(*Chairman.*) I think it can only be called what is known as approximate evidence.

(*Mr. Bidder.*) I venture to think it is not even that.

(*Mr. Lumley Smith.*) Dealing with a case in which it is said that it is impossible to have any accurate observations, we must take what we can get.

(*Mr. Bidder.*) Suppose that Croydon, for example, were a place in which there were only three houses and 20 people, and the rainfall of a square mile got into the sewer; the difference between the sewage and the tenth of an inch of rain would be enormous; but supposing you have 20,000 people upon that area, you have just the same amount of rain falling, and a thousand times the quantity of sewage.

7822. (*Sir John Coode.*) No doubt; and there is also the question of the soil, whether it is retentive, or otherwise. What is Croydon?—Some parts chalk and some parts gravel, other parts London clay, and other parts the Woolwich and Reading beds.

7823. (*Chairman.*) We might ask you what is the population of Croydon compared with the area over which it is spread; it is not so dense as in London?—Nothing like it. The population of that part to which I am referring is something over 60,000; it is about three square miles, and there are 60,000 people upon it, making 20,000 to the square mile.

(*Sir John Coode.*) If the Metropolitan Board of Works can give us observations over a considerable portion of their sewers, extending over a considerable period of years, we had far better deal with the facts, if the facts are sufficient to form a conclusion upon.

(*Mr. Lumley Smith.*) From Sir Joseph Bazalgette's evidence I inferred that they were not in a position to give us those facts from these overflows being self-acting.

(*Sir John Coode.*) If they can do it, then all this is wasting time, I imagine. If they cannot, then this evidence is valuable.

(*Chairman.*) Suppose the Metropolitan Board of Works can give us statistics or figures upon this matter, Mr. Latham will have an opportunity of seeing them. If he says these figures require explanation or do not give you the whole truth, he will have an opportunity of coming before us again and telling us that.

7824. (*Mr. Lumley Smith to the witness.*) Then, without going more into detail, I will ask you the general question; what is the inference which you draw as to the London sewers from your observations at Croydon; is it summed up by what you have told us, that the number of overflows in London would be more than has been estimated in the evidence which has been given?—I say so, most decidedly.

7825. Could you form any opinion as to the number of times in a year when overflows would probably happen?—The only part of the Metropolis that we really know anything about with regard to the volume of the sewage is upon the south side; and there I think the ratio of the flow in time of rain to the mean flow is shown to be about 3 to 1; the exact quantity is 2·76 to 1.

7826. (*Chairman.*) That is to say, that if the rain were about double the sewage it would fill the sewer?—It would.

7827. And you say it would be often more?—My observations enable me to say so from this district, which bears a very fair comparison to the south side of London.

7828. Taking that district, how often would the sewers be incapable upon the south side?—Upon the average, every time rain occurred the sewers must overflow in the case of London.

7829. Whenever it rained?—Whenever it rained, at some point or other they must overflow.

7830. (*Mr. Lumley Smith.*) Now I pass on to a matter connected with the actual reservoirs that are at present employed. You were asked a question upon a previous occasion as to the capacity of the reservoirs?—I was asked whether the reservoirs were of sufficient capacity to deal with the dry-weather sewage. I answered, yes; but I had in my mind that we were only dealing with the south of the Thames, and dealing with the quantity which it was originally calculated by the board's engineer would have to come down; they are not competent to deal with the quantity which actually comes down.

7831. That is to say, upon the south side?—Upon the south side.

7832. That is to say, that in the twelve hours of tide they do more than fill?—Yes, the tidal period is 12½ hours. We may take it for the purpose of calculation. Now originally, from the report of Messrs. Bidder, Hawksley, and Bazalgette, of the 6th of April 1858, those were to discharge for 2½ hours. Of course they must therefore hold 10 hours' sewage. There being 1,200,000 people upon the south side, representing about 10,000,000 cubic feet of sewage per day, and assuming that half the total sewage flows off in nine hours, which is the rate it is now shown to be flowing off at, it is quite clear that a reservoir which only holds 4,000,000 cubic feet cannot hold 10 hours' sewage; but if, as appears to have been already given in evidence before you by Sir Joseph Bazalgette, you increase the time of discharge and limit the period of storage, you can make the reservoir hold anything

*Mr. B. Latham, M. Inst. C.E.*

30 Jan. 1883.

you like; in fact, in this case you see the reservoirs have been made to hold eight hours' storage only.

(*Mr. Bidder.*) May I be allowed to suggest whether it is worth while to waste time about this, when Sir Joseph Bazalgette has said that the Metropolitan Board of Works are only awaiting the result of this inquiry to enlarge the reservoirs. They have come to the conclusion that the reservoirs are not large enough, and are only waiting for an opportunity to enlarge them. It is conceded by both sides.

(*Witness.*) I am referring to questions 57 and 58 on page 8 of the evidence given before the Commission, and question 145 on page 14. You will there see that the time of discharging upon the ebb is increased to four hours, and the time of the storing is eight hours. Of course the result of that is that the sewage must come very much further up the river if it is discharged for four hours, instead of two-and-a-half hours as originally contemplated.

7833. (*Mr. Lumley Smith.*) What is the conclusion you have come to?—The conclusion I have come to is that on both sides of the river the reservoirs are very much too small, but immeasureably so upon the north side; because, as you will observe, the reservoir upon the south was to accommodate 1,094,600 people according to the original estimate, and to hold 4,000,000 cubic feet. Assuming that the reservoir upon the north holds 39,000,000 gallons, which is one of the estimates (35,000,000 is given in this inquiry), it will only accommodate at the same rate at which the south provides 1,707,576 people; whereas the actual population upon the north is very much greater than that; and this 1,707,576 is very much less than the population which it was originally estimated had to be dealt with upon the north; but that is no doubt due to the fact of their having brought the western sewage there without having enlarged the reservoir. If the reservoir upon the north side had been made to hold the 9,000,000 cubic feet which it was reported by Sir Joseph Bazalgette it must hold if they brought the western district sewage there, it would have accommodated the population which was estimated; but, seeing that it was not enlarged, it would only accommodate a very much smaller population in the proportion that the south was provided for.

7834. (*Mr. Lumley Smith.*) Then all the sewage which cannot be provided for must be let into the river at one place or another, regardless of the tide?—Yes; upon the north, as I have pointed out, the reservoir, if it held 39,000,000 gallons, would only hold the sewage which the three northern outfall sewers, if running full, would bring down in 2·8 hours.

7835. (*Chairman.*) So that there would be an overflow or an outlet for the rest of the 12 hours?—Yes, assuming the sewer was still running full.

7836. But there is a period when it does not run full?—There would be periods when it did not run full.

7837. (*Sir John Coode.*) Assuming the sewers were all running full?—Assuming the northern outfall sewers bring to the reservoir all they can, then the reservoir would only hold that quantity of sewage for 2·8 hours, and upon the south side they would fill in $3\frac{1}{3}$ hours.

7838. (*Chairman.*) You mean that there are periods in the 24 hours when the flow of sewage is small comparatively?—There are.

7839. How much of the whole day of 24 hours would the reservoirs hold?—That would all depend upon whether there was rain or not.

7840. If there were not?—If there were no rain, then I have already pointed out that in nine hours upon the south side (we know nothing as to the north) one-half of the sewage would flow into the reservoir.

7841. Why in nine hours?—Owing to that fluctuation of the flow.

7842. Would that fill it?—Upon the south side it would more than fill the reservoir, with the present population.

7843. If that were the worst, they could then open their sluices and let it out, could they not?—That is no doubt what they do.

7844. Then there would not be an overflow there?—They may let it out by means of self-acting overflows, or they may open the sluices or pump it out.

7845. The reservoir would be capable of holding the sewage until it was time to discharge it?—There are provisions made, in case of the reservoir getting full, that it shall overflow into the river.

7846. What I mean is that, if it takes nine hours to fill it in dry weather, then the discharging process begins, because three hours out of the ebb would be sufficient to empty it?—Three hours it would take; but still that quantity, with the present population taken at 8 cubic feet per head, more than fills the southern reservoir.

7847. In other words, they are obliged to let it out before they would let it out if they could help it?—The reservoirs are too small for the present population, and therefore they cannot retain it.

7848. Cannot they let it out during the whole of the ebb?—If they did, the last that went out would come up again 12 miles above the outfall.

7849. Do you know how long, as a fact, before the beginning of flood tide they stop the outflow?—It is given in evidence that it is four hours after high water. My observations tended to show that it must be three hours, because upon many occasions the level of the water would not fall sufficiently low to enable them to empty the reservoirs until that three hours had elapsed.

7850. (*Mr. Lumley Smith.* The water in the Thames does not sink to the level of the outfall until three hours after high water?—Not until three hours after high water.

7851. With regard to the levels of the outfall, have you any observations to make upon the actual level?—I have already drawn attention to the question of mean tide level.

7852. Is that summed up in the conclusion you have come to that it would generally be three hours after high water before the water sank to the level of the reservoir?—Yes, I find some evidence given by Sir Joseph Bazalgette upon this inquiry at questions Nos. 56 and 57, which, if correct, show the mean tide level to be 2 feet $5\frac{1}{2}$ inches instead of 1·56 above datum the figure he has given.

7853. (*Chairman.*) Is the mouth of the outfall of the sewer into the reservoir below the level of high water?—It is somewhat below high water; the invert is put down at 11·4, but they lose that fall by letting it into the reservoir, the floor of which is only 2·75 above datum; and you recollect, from the evidence which was given in the original tidal observations it was insisted upon as a point of great importance that the level of the outfall should be 9 feet above ordnance datum.

7854. The height of the water in the reservoir is never higher than the mouth of the sewer, otherwise it would be penned back, up the sewer?—It may be so.

7855. But it is not meant to be so?—No; for this reason, that the sewers are 9 feet high, and if you add 9 feet to 11·4, that would bring you to 20·4 above ordnance datum. Now Trinity high water is 12·5 feet above datum, so that, though it is above the invert, high water would not be above the crown of the sewer upon any occasion. I was going to observe also that in the Report of Messrs. Hawksley and Bidder of the 6th of April 1858 they point out that the level of the outfall ought to be 10 feet above ordnance datum. In the original scheme of the Metropolitan Board of Works (that is, the scheme proposed by Sir Joseph Bazalgette and Col. Haywood), these reservoirs were intended to be made in a totally different way. They were intended to be made by enlarging the lower portion of the sewers themselves instead of making the reservoirs at a lower level than the sewers. I have no doubt in my own mind that these reservoirs were made with the object of treating

the sewage; and that accounts for the level and the mode in which they were constructed.

7856. (*Mr. Lumley Smith.*) By "treating the sewage" you mean chemically, or in some other way?—Yes; it is quite clear from the Reports of the engineers that they intended to treat the sewage at the outfall, especially in the summer months.

7857. (*Chairman.*) Is the bottom of the reservoir at a lower level than what you may call the lower lip of the sewer?—Many feet.

7858. You could build up the sides of the reservoir, and that would become a matter immaterial, would it not?—No; because they have put the reservoir below the level of the sewer.

7859. If the sewer runs into the reservoir, and if you build the walls high enough, you will have still the sewer underneath the walls of the reservoir?—But the reservoir is made at a different level of several feet, and the great object is to discharge the sewage upon the top of the tide, but owing to having put the level of the floor so low it cannot fully discharge until three hours after high water, and cannot be discharged so readily as if it had been at a level of 10 feet.

7860. If you could raise it bodily up, that would be obvious; but suppose you leave the floor where it is, you never empty it; but it would not matter much, would it, if there were a quantity always in it?—Yes; that mass of matter which could not be got rid of would undergo putrefaction and make the sewage more offensive than it is at present.

(*Mr. Bidder.*) We do empty it to the bottom.

(*Chairman.*) I understand the witness to say that the floor of the reservoir is so low that you cannot avail yourself of the whole of the ebb.

(*Mr. Bidder.*) It is not quite so; it would be more accurate to say that the floor is at such a level that you cannot finish your discharge until half ebb.

7861. (*Chairman.*) Then, I ask, why cannot you obviate that by raising the floor? Could you obviate it by raising the floor?—If you made the reservoir upon a higher level altogether, you could.

7862. Could the sewers then flow into it, or would they be too low to flow into it? If you raised the water in the reservoir, would there be an injudicious penning back of the water up the sewer?—It is quite possible that there might be, and that it would require an enlargement of the discharging capacity of the sewer to obviate that.

7863. Would the gorging of the sewers be objectionable?—It would be, but that could be got over, because the fall in a sewer does not really depend upon the fall of the invert; it is the fall of the surface of the water. As long as we can maintain a sufficient fall of the surface of the water to give sufficient discharging capacity to keep the sewer clear, that could be got over.

7864. It is not an open sewer at the top, is it?—No, it is arched over all the way.

7865. (*Mr. Lumley Smith.*) Merely increasing the area of the reservior would not diminish the defects arising from the depth of the level?—No.

7866. Do you know how long, having regard to the levels, it would take to discharge what is left in the reservoirs after the tide gets to the level of the bottom of the floor?

(*Mr. Bidder.*) The floor of the reservoir is one foot above half tide level, therefore it comes down to the floor before three hours ebb.

(*Chairman.*) Therefore one would think you could empty it in the first three hours of the ebb.

(*Mr. Bidder.*) So we can.

7867. (*Mr. Lumley Smith to the witness.*) I understand that that is not your view.

(*Chairman.*) I thought it was admitted that they could not empty it in the first three hours of the ebb.

(*Witness.*) At questions 57 and 58 evidence is given as to four hours being occupied in the discharge.

7868. (*Mr. Lumley Smith to the witness.*) You have taken from your observations the exact mean half tide?—I say that these observations in Sir Joseph Bazalgette's evidence with regard to the half tide are incorrect.

7869. (*Mr. Bidder.*) Your Lordship will find that Sir Joseph Bazalgette has given the figures; he says "the "bottom of the reservoir is +2·75 feet, or 1·19 feet "above half tide." Will you indicate which of those figures, if any of them, are wrong, and how?—I am going to do so. In answer to question No. 56 it is stated that, "Trinity high water is 12 feet 5 inches "above Ordnance datum; low water is 7 feet 6 inches "below datum." I mean to say, that if you take the mean of those two it shows that the mean half tide level is 2 feet 5½ inches above Ordnance datum. Now I have pointed out already from the observations we have made in the river that we make the mean half tide level nearly 2 feet at this point, which agrees within half an inch with this diagram No. 9. in the engineers' reports of the 6th April 1858.

7870. (*Mr. Bidder.*) Trinity high water, which Sir Joseph Bazalgette gives in answer to question No. 56, is a creature of Parliament, I think; it is a thing fixed by statute, and does not necessarily show what the real facts are?—But this is not a thing created by statute.

(*Chairman.*) That is so. Trinity high water is an arbitrary point fixed by law.

(*Mr. Lumley Smith.*) And that makes Sir Joseph Bazalgette's evidence less valuable to us, because it is dealing with a hypothetical standard.

(*Witness.*) Mean high water is shown at 11 feet above Ordnance datum upon this diagram, and mean low water at 7 feet below Ordnance datum, and half tide at 1·5. Now, anyone who calculates the mean between these figures, will see that the mean level of half-tide ought to be 2 feet and not 1·5.

7871. What is the practical result with regard to the position of the outfall in reference to mean half tides?—We know from the Crossness observations, where they have given us the level inside and outside the reservoir during the discharge, that there is always a considerable difference between the level inside and outside the reservoir, so that the reservoir practically never can empty until half tide level.

7872. (*Chairman.*) You mean they cannot finish emptying?—That is so.

7873. (*Mr. Lumley Smith.*) When it gets to the level what is left in the reservoir; is it all empty then, or is there still more left?—It may empty; the passages from the reservoir are sufficiently capacious to empty it.

7874. Your practical result is that it would empty itself at the half tide?—Yes. I may here point out another fact, which is also important in relation to the discharging of the reservoir, that in Mr. Rawlinson's inquiry, which was held at Barking, the gentleman in charge of these reservoirs gave evidence stating that the time during which discharging could take place was three hours, and sometimes three and a half hours; that is Mr. Cooper's evidence.

(*Mr. Bidder.*) I do not know who Mr. Cooper was; he may have been right or he may have been wrong.

(*Witness.*) He was the Metropolitan Board of Works engineer.

7875. (*Mr. Lumley Smith.*) I will pass on now to another matter. I believe you have calculated, have you not, the amount of actual solid matter that is every year discharged into the river Thames from the metropolitan sewage?—I have.

(*Mr. Bidder.*) Do you mean from the sewers?

7876. (*Mr. Lumley Smith.*) From the sewers. (*To the witness.*) Now your first calculation is based, is it not, upon an experiment which you mentioned last Tuesday in answer to question 7434, made by the Metropolitan Board of Works, as to the A B C process? Upon that experiment you base your calculation with regard to the quantity of solid matter which goes into the Thames?—Yes, that is one way in which I have estimated it.

7877. The A B C process, as I understand, is a process of treating sewage with certain matters, such as alum, blood, and clay?—Yes.

*Mr. B. Latham, M. Inst. C.E.*

30 Jan. 1883.

7878. For the purpose of seeing if it could be made into useful manure?—The materials in this case I believe were sulphate of alumina, charcoal, and clay, with a little blood and lime occasionally.

7879. I will ask you a little more in detail with regard to that experiment, because I do not think my learned friend agreed with the conclusion at which you arrived. The experiment was made by the Metropolitan Board of Works in 1872, that is to say, it was made by the Native Guano Company with the sanction of the Metropolitan Board of Works?—That experiment was carried out at the cost of the Native Guano Company, but under the direct control of the officers of the Metropolitan Board of Works.

7880. I should like, with his Lordship's permission, to have upon the notes the way in which you arrive by that experiment at the quantity of the solid matter in the sewage. This was an experiment made for the purpose of seeing what amount of solid matter was in the sewage, and what amount of manure could be produced?—It was an experiment made, I presume, both to test the purifying result of the process and the amount of manure produced.

7881. I believe at that time there were treated a number of gallons of sewage. Can you give me the number of gallons that were treated?—It is given in the report. I have the original report of the Metropolitan Board of Works here.

7882. Will you just give me the actual number of gallons?—At page 4 of Sir Joseph Bazalgette's Report of the 11th January 1873, the actual number of gallons of sewage experimented upon is stated to be 11,672,737, being $\frac{1}{343}$rd of the average flow of the sewage discharged at Crossness, and $\frac{1}{686}$th of the sewage of London.

7883. Now, will you tell me what was done. I believe to the sewage was added a quantity of dry materials?—Yes.

7884. How much was added?—The material was not added in a dry state, it was added in a wet state; but it was equivalent to 81 tons of dry material, according to the report.

7885. That was added to the sewage?—That was added to the sewage—that was the dry material of the A B C mixture.

7886. What did that produce?—It produced 142 tons of manure.

7887. How much of those 142 tons of manure was found to consist of water?—26·45 per cent.

7888. Then, when you deduct the quantity of water from the manure you retain, how much do you get of dry matter?—The amount of dry matter left was 104·441 tons.

7889. That you have got by adding 81 tons of dry matter, do you find that any portion of the 81 tons is passed away in effluent water?—Yes.

7890. Can you tell me how much of the 81 tons has gone away, and how that is arrived at?—Mr. Keates gives an analysis of the effluent water and also of the sewage, and by adding up from page 16 the total quantities of matter in solution in the raw sewage, it is shown that there were 72 grains of matter in solution in a gallon of the raw sewage.

7891. Those were salts in solution in the sewage?—Yes.

7892. But in the effluent water how much did you find in solution?—In the effluent water they give the figure at 98·70 grains.

7893. Therefore the difference between those two in the effluent water must have come from the dry material?—Yes.

(*Chairman.*) Are you not a little cross-examining your own witness, as it were; had you not better ask him what his conclusions are at once, and then if the other side have a mind to cross-examine, let them; you might, perhaps, ask the witness whether he could tell what quantity of solids were found in a given portion.

7894. (*Mr. Lumley Smith.*) How much, therefore, do you have to add to the 104·441 tons of dry material in the sewage to show what solid matter was taken from the sewage?—19·87 tons require to be added to the 104 tons, and then you have to deduct the 81 tons of the original A B C mixture, and you then have 43·31 tons of solids in suspension, a result equal to 57 grains in a gallon.

7895. If you multiply that by 686, how much do you get in 80 days?—You get 29,610 tons in the 80 days, and that in that same year it would be equal to 135,096 tons.

7896. Then all that solid matter goes into the river in one year?—Yes, all that solid matter goes into the river in one year from the sewers.

7897. (*Mr. Bidder.*) That is in suspension?—Yes, that is in suspension; that was in 1872. At the present time, allowing for the increase of population, and taking the sewage which has been given to us as 148,163,267 gallons per day, it shows that the quantity of solid matter going into the river is at the rate of 197,647 tons per annum.

7898. That is making correction for increased population?—Yes.

7899. (*Mr. Lumley Smith.*) That assumes that the A B C experiment was a fair test?—Yes.

7900. Is there any reason for thinking that at that time the solid materials were in excess or below the usual amount?—The report says that the sewage was abnormally weak, and from what I have stated of there having been so many more gallons per head of water leakage upon the south than upon the north, there is every reason to believe that it is under-estimated if it were applied to the whole of the metropolis; but I have taken that as the basis of calculation for the whole of the metropolis, and the quantity passing into the river as the quantity passing into the river in the year.

7901. This matter is partly fœcal matter and partly detritus of roads and so on?—It is.

7902. Have you made an estimate at all for the purpose of seeing what would probably be the amount of fœcal matter contained in the sewage as compared with the amount of road scrapings and other matters?—It is probably hardly worth while taking the solid part of the sewage of the population, because some part of the matter is always in solution; but I have taken other modes of arriving at the quantity. For example, we know that the amount of dry matter produced by the population is $3\frac{1}{2}$ ounces per head per day of the population. And of that a part would be in solution, so it would not be fair to assume that as all being in suspension; but there are other matters in addition to the fœcal matter which would take the place of that in solution, so that would not be a very unfair estimate of the solid contents contributed by the population to the sewers. Taking $3\frac{1}{2}$ ounces per head upon the 3,894,028 population it comes to 380·27 tons per day, which would be equal to 138,789½ tons in the year.

7903. Then by this ordinary estimate the dry matter per head comes to roughly 138,000 tons. How do you explain the difference between the 138,000 tons which you get in that way and the 198,000 tons that you get by your A B C experiment?—There would be very much of other solid matter going into the sewers. I have made experiments at Croydon with regard to the solid matter there, and we found that by passing it through a quarter of an inch grating one half of the solid matter in suspension is removed, one half goes to the sewage farm, and one half is removed, one-tenth of a pound per head per day is removed by extractors, and one-tenth of a pound per head per day goes on to the farm; so I find that the solid matter in suspension is one-fifth of a pound per head per day.

7904. (*Dr. De Chaumont.*) When you speak of $3\frac{1}{2}$ ounces of solid matter you mean all the water being drawn off?—Yes.

7905. (*Mr. Lumley Smith.*) Do I understand that the difference between the 138,000 tons and the 197,000 tons of the A B C experiment is due to the road scrapings and other foreign matter?—It is due to the road scrapings and other foreign matter. As I

have already pointed out in the case of Croydon, the roads do not drain into the sewers, but if you take one-fifth of a pound per head it is not very different from the 3½ ounces.

7906. So that your view is that of fæcal matter alone you get 138,000 tons, and of general solid matter 197,000 tons?—Yes; in the case of the A B C experiments, roundly, 200,000 tons in the year.

7907. With regard to this solid matter, you do find in the report of Messrs. Bidder, Hawksley, and Bazalgette, of 1858, at page 74, an estimate given, do you not?—Yes.

7908. What do you find is the estimate given in 1858?—I find that 250 tons a day are estimated as the amount of solid matter passed into the river; that was taken at 91,250 tons in the year.

7909. The population has increased from how many in 1857?—The population has increased from about 2,685,000 in 1857 to 3,894,000 in 1882.

7910. So that at the same rate what would the solid matter now be per day?—At the same rate the solid matter would now be 362½ tons per day, or in a year 132,312 tons.

7911. That agrees pretty nearly with the result you have got by taking the 3½ ounces?—Yes, or by taking one-fifth of a pound per head per day.

7912. Now a question upon a matter which stands by itself. I believe that the Beckton Gasworks outfall sewer, of which we have heard occasionally, has been gauged by you, has it not?—Yes. I made inquiries with regard to the Beckton Gas outfall, and I found that it was constructed in 1874, or 10 years after the northern outfall sewer had come into operation. I have had the quantity of sewage or water which flows out of it gauged, and I found that, on the average of nine days, the total quantity of water flowing out of it was 32·55 cubic feet a minute, or 292,952 gallons per day; or, if you take it in cubic feet, 46,872 cubic feet per day; that is the average of nine days, gauging night and day.

7913. (*Chairman.*) Has that a separate outlet into the river?—It has.

7914. By what law is that?—Anyone can have an outlet into the river for drainage purposes, provided he does not pollute the river. In this case, at Beckton, they have a reservoir for purifying the sewage; it is purified through coke, and very carefully treated, so that no solid matter goes into the river; but the water smells very strongly of gas.

7915. (*Colonel Ewart.*) Does that bring any sewage except the sewage of the gasworks?—There are 101 cottages upon the gasworks property, and it drains them.

7916. (*Sir John Coode.*) But did you not say that the solids were all filtered out?—Yes; there are purifying tanks, and there is a man always looking after them. Samples of water have been taken by our chemist for the purpose of analysis, and no doubt will be produced before you.

7917. (*Mr. Lumley Smith.*) With regard to the effect of taking the sewage of London to the outfalls at Barking and Crossness instead of discharging it, as it used to be discharged, in London proper, would that, in your judgment, have any effect upon the water or upon the tides in the river?—Yes.

7918. What is your view about it? The result is this, is it not, that the water which is supplied by the water companies to London, instead of being discharged into the Thames in London, is discharged now at Crossness and Barking, is it not?—Yes.

7919. The water which is supplied to the houses passes out into the sewers, and goes out into the river at a lower point than it formerly did; is that so?—Yes.

7920. What is likely, in your judgment, to be the result of that?—From this table, prepared by Mr. Mansergh, which I will now hand in, it will be seen that, by deducting the volume of fresh water entering the river at Teddington, you get the quantity of tidal water entering the river, and whether there is a large quantity or small quantity coming down, there is very little difference in the tidal capacity; that being so, it is clear that the effect of moving a large body of water from the upper part of the river and discharging it in the lower part is, as it were, to create a vacuity in the upper part, and then, when the tide begins to flow up, there is a certain tendency for the tide to occupy that position which had hitherto been occupied by the water which had flowed down the river; so that the effect of moving the outfalls to these points was really also to create a tendency for the tidal water to bring the sewage back again.

*The table was handed in, and is as follows:—*

TABLE of CAPACITY of RIVER THAMES. Prepared by Mr. JAMES MANSERGH, M. Inst. C.E.

To which has been added the Volume of Fresh Water entering the River.

| | Two Days after High Water Spring Tide. | Two Days after High Water Spring Tide. | Neap Tide. | Neap Tide. |
|---|---|---|---|---|
| Tidal water above synchro-surface lines, Teddington to Southend | 1st Oct. 9h. 28m. A.M. to 3h. 8m. P.M. | 30th Oct. 9h. 20m. P.M. to 3h. 15m. A.M. 31st | 6th Oct. 1h. 7m. A.M. to 7h. 37m. A.M. | 4th Nov. 1h. 0m. A.M. to 7h. 10m. A.M. |
| | Cube feet. 20,296,232,680 | Cube feet. 20,598,501,011 | Cube feet. 10,914,013,084 | Cube feet. 10,496,748,630 |
| Volume of fresh water entering river | 61,400,087 | 462,893,020 | 55,855,800 | 262,216,780 |
| Tidal water entering river | 20,234,832,593 | 20,135,607,991 | 10,858,157,284 | 10,234,531,850 |
| Tidal water above synchro-surface lines, Barking to Southend | 18,576,054,395 | 18,905,450,703 | 9,888,777,284 | 9,476,250,993 |
| Low-water content Barking to Southend | 17,736,971,361 | 17,433,521,276 | 21,551,899,564 | 19,539,139,333 |
| Total content of river, Barking to Southend | 36,313,025,756 | 36,338,971,979 | 31,440,676,848 | 29,015,390,326 |

*Mr. B. Latham, M. Inst. C.E.*

30 Jan. 1883.

7921. (*Chairman.*) What proportion is the supply of the water companies compared with the fall over Teddington Lock?—It varies immensely; in a dry period it would not be more than a fourth part of it.

(*Mr. Bidder.*) It is about an eighth upon the average. I took that from the witness's own statements.

7922. (*Chairman.*) I do not know whether it is worth noticing that the New River and the River Lea are great suppliers?—The River Lea in dry weather has very little water coming down it; it is all taken by the water companies.

7923. (*Chairman.*) It flows out at Blackwall?—Yes; but formerly it was distributed in other parts as well, by the water companies.

(*Mr. Lumley Smith.*) The New River does not get into the Thames.

(*Witness.*) The present water supply, by which I am speaking of that taken from the Lea as well as from the Thames, would not be a third in dry weather of what comes, over Teddington Lock; it is about 149,000,000 gallons a day; that was in 1881 the total average daily supply from all sources.

7924. (*Prof. Williamson.*) Apart from the quantities, I should like to understand what you mean exactly by the statement you have just made, that the fact of sewage being discharged lower down the river caused the sewage to go up higher?—That same volume previously filled the channel of the river when it was put in higher up; but taking that down to a lower point and holding it to a certain period of the tide, has created a vacuity in this upper part.

7925. And there is not so much poured in higher up?—It was formerly poured in all the way up the banks, but it is now only discharged upon the ebb tide, and therefore there is no discharge taking place to fill this upper part of the channel, so that the channel having been robbed of a portion of its water, a greater amount of tidal water must come in to fill its place.

7926. Some of the sewage is brought up by the tide instead of being poured in direct?—So much more comes up.

7927. But that cannot be so much as if it had been poured in straight.

7928. (*Chairman.*) Suppose that by some contrivance they diverted a fourth of the water that comes over Teddington Lock, and it never came into the river at all, then you say the tidal water would come higher up?—The tidal water would fill up that vacuity.

7929. But, practically, if they discharge it at a lower place, it comes up still more?—It comes up still more, because it has a tendency to create an artificial flood at that point, and it flows up still further.

(*Mr. Bidder.*) If that argument be correct, it points out that we ought to revert to the old state of things.

(*Witness.*) In this particular report of 1858 my attention was directed to the amount of solid matter which used in 1857 to be found at various points of the river, and our chemists will show you that it gets up to a much higher point than it previously used to do, which is a corroboration of what I have been stating.

7930. (*Mr. Lumley Smith.*) The next table you have to produce is a table of the proportion of death-rate annually at Barking town, Essex, and other places?—Yes.

7931. How have you obtained those?—Those are the actual figures taken from the quarterly returns of the Registrar General.

7932. You have them at Barking town, at Grays, at Dartford, and at Gravesend?—Yes; but I must point out that those are the registration districts which comprise more than the towns themselves; those are the districts abutting upon the Thames. Dartford includes Erith and all that district, and so with Gravesend; those are the actual registration districts.

*The tables were handed in, and are as follows:—*

POPULATION and DEATH RATES ANNUALLY at BARKING TOWN, ESSEX.

| Year. | Population on 30th June. | Births and Deaths. | | | Rates per Thousand. | | | |
|---|---|---|---|---|---|---|---|---|
| | | Births. | Total Deaths. | Zymotic Deaths. | Rate of Births. | Rate of Total Deaths. | Rate of Zymotic Deaths. | Births divided by Deaths. |
| 1871 | 6,627 | 236 | 110 | 16 | 35·61 | 16·60 | 2·41 | 2·14 |
| 1872 | 6,850 | 286 | 156 | 47 | 41·75 | 22·77 | 6·86 | 1·83 |
| 1873 | 7,080 | 303 | 140 | 15 | 42·80 | 19·77 | 2·12 | 2·16 |
| 1874 | 7,319 | 297 | 139 | 11 | 40·58 | 18·99 | 1·50 | 2·14 |
| 1875 | 7,565 | 307 | 190 | 43 | 40·58 | 25·12 | 5·68 | 1·62 |
| 1876 | 7,820 | 311 | 113 | 12 | 39·77 | 14·45 | 1·53 | 2·75 |
| 1877 | 8,083 | 350 | 126 | 7 | 43·30 | 15·59 | 0·87 | 2·77 |
| 1878 | 8,355 | 369 | 194 | 24 | 44·17 | 23·22 | 2·87 | 1·90 |
| 1879 | 8,637 | 348 | 179 | 37 | 40·29 | 20·73 | 4·28 | 1·94 |
| 1880 | 8,927 | 374 | 180 | 28 | 41·89 | 20·16 | 3·14 | 2·08 |
| 1881 | 9,228 | 382 | 180 | 25 | 41·40 | 19·51 | 2·71 | 2·12 |
| | | | | | | | | 2·13 |

POPULATION and DEATH RATES ANNUALLY at GRAYS, ESSEX.

| Year. | Population on 30th June. | Births and Deaths. | | | Rates per Thousand. | | | |
|---|---|---|---|---|---|---|---|---|
| | | Births. | Total Deaths. | Zymotic Deaths. | Rate of Births. | Rate of Total Deaths. | Rate of Zymotic Deaths. | Births divided by Deaths. |
| 1871 | 7,618 | 210 | 110 | 24 | 27·57 | 14·44 | 3·15 | 1·91 |
| 1872 | 7,868 | 245 | 124 | 32 | 31·14 | 15·76 | 4·07 | 1·98 |
| 1873 | 8,127 | 249 | 109 | 12 | 30·64 | 13·41 | 1·48 | 2·28 |
| 1874 | 8,394 | 278 | 128 | 31 | 33·12 | 15·25 | 3·69 | 2·17 |
| 1875 | 8,669 | 312 | 171 | 37 | 35·99 | 19·73 | 4·27 | 1·82 |
| 1876 | 8,954 | 285 | 119 | 16 | 31·83 | 13·29 | 1·79 | 2·39 |
| 1877 | 9,248 | 306 | 121 | 9 | 33·09 | 13·08 | 0·97 | 2·53 |
| 1878 | 9,552 | 339 | 142 | 27 | 35·49 | 14·87 | 2·83 | 2·39 |
| 1879 | 9,865 | 366 | 138 | 29 | 37·09 | 13·99 | 2·94 | 2·65 |
| 1880 | 10,189 | 374 | 159 | 35 | 36·71 | 15·61 | 3·43 | 2·35 |
| 1881 | 10,524 | 403 | 155 | 39 | 38·29 | 14·73 | 3·71 | 2·60 |
| | | | | | | | | 2·28 |

POPULATION and DEATH RATES ANNUALLY at DARTFORD, KENT.

| Year. | Population on 30th June. | Births and Deaths. | | | Rates per Thousand. | | | |
|---|---|---|---|---|---|---|---|---|
| | | Births. | Total Deaths. | Zymotic Deaths. | Rate of Births. | Rate of Total Deaths. | Rate of Zymotic Deaths. | Births divided by Deaths. |
| 1871 | 16,557 | 584 | 320 | 55 | 35·28 | 19·33 | 2·64 | 1·82 |
| 1872 | 17,065 | 641 | 285 | 38 | 37·65 | 16·74 | 2·23 | 2·25 |
| 1873 | 17,589 | 589 | 318 | 37 | 33·49 | 18·08 | 2·10 | 1·85 |
| 1874 | 18,129 | 629 | 371 | 68 | 34·70 | 20·46 | 3·75 | 1·70 |
| 1875 | 18,685 | 561 | 356 | 37 | 30·02 | 19·05 | 1·98 | 1·58 |
| 1876 | 19,258 | 643 | 375 | 55 | 33·39 | 19·47 | 2·86 | 1·72 |
| 1877 | 19,849 | 663 | 450 | 12 | 33·40 | 22·67 | 5·64 | 1·47 |
| 1878 | 20,458 | 652 | 357 | 41 | 31·87 | 17·45 | 2·00 | 1·83 |
| 1879 | 21,086 | 706 | 405 | 32 | 33·48 | 19·21 | 1·52 | 1·74 |
| 1880 | 27,733 | 757 | 445 | 51 | 34·83 | 20·47 | 2·35 | 1·70 |
| 1881 | 22,400 | 751 | 466 | 60 | 33·53 | 20·80 | 2·68 | 1·61 |
| | | | | | | | | 1·75 |

POPULATION and DEATH RATES ANNUALLY at GRAVESEND, KENT.

| Year. | Population on 30th June. | Births and Deaths. | | | Rates per Thousand. | | | |
|---|---|---|---|---|---|---|---|---|
| | | Births. | Total Deaths. | Zymotic Deaths. | Rate of Births. | Rate of Total Deaths. | Rate of Zymotic Deaths. | Births divided by Deaths. |
| 1871 | 21,303 | 639 | 381 | 48 | 30·00 | 17·89 | 2·25 | 1·68 |
| 1872 | 21,506 | 638 | 407 | 56 | 29·67 | 18·92 | 2·60 | 1·57 |
| 1873 | 21,712 | 588 | 419 | 41 | 27·08 | 19·30 | 1·89 | 1·40 |
| 1874 | 21,920 | 646 | 466 | 55 | 29·47 | 21·26 | 2·51 | 1·39 |
| 1875 | 22,129 | 632 | 455 | 71 | 28·56 | 20·56 | 3·21 | 1·39 |
| 1876 | 22,340 | 718 | 401 | 81 | 32·14 | 17·95 | 3·63 | 1·79 |
| 1877 | 22,554 | 706 | 465 | 98 | 31·30 | 20·62 | 4·34 | 1·52 |
| 1878 | 22,769 | 704 | 504 | 107 | 30·92 | 22·14 | 4·70 | 1·40 |
| 1879 | 22,986 | 698 | 382 | 35 | 30·37 | 16·62 | 1·52 | 1·83 |
| 1880 | 23,206 | 686 | 411 | 50 | 29·56 | 17·71 | 2·15 | 1·67 |
| 1881 | 23,428 | 669 | 408 | 58 | 28·56 | 17·42 | 2·48 | 1·64 |
| | | | | | | | | 1·57 |

7933. Do those give us the actual figures, and do you draw any conclusions from them which you desire to bring to the attention of the Commission?—Yes. I think the figures show considerable fluctuations in the death-rate which are not really consonant with very healthy districts. There are some districts at times which have a marked degree of health.

7934. I see it varies very much in the column showing the deaths from zymotic diseases?—The most unhealthy district of all, in my opinion, is shown to be Erith—that is, the Dartford district—when tested in a particular way. The way in which I look at them is, by comparing the birth-rate as it affects the death-rate; if you divide the births by the deaths it gives you a better result of the state of health in the way of gain to the country than the actual death-rate. Out of the total number of births a very large proportion of deaths takes place, perhaps 25 per cent. in the first year, and where there is a large birth-rate, it materially affects the death-rate; therefore I say that if you simply divide the births by the deaths it will show you what was the gain to the country in any particular district, and treating these districts in that way it puts a very different complexion upon some of these places.

7935. (*Mr. Bidder.*) We have the births divided by the deaths; that is a fraction?—Whenever the number is above two you may say the place is healthy; if it falls under double the death-rate, then you may say in proportion as it falls under that it is unhealthy.

7936. Is a place unhealthy or healthier in proportion as the fraction gets bigger or smaller?

7936*a*. (*Chairman.*) The witness says if you divide by two it is an average condition of health?—It is a good condition of health.

7937. But if it would divide by three it would be wonderfully good?

(*Mr. Bidder.*) That is to say, if the births were three times the number of the deaths.

(*Witness.*) That would be too much to expect.

7938. (*Chairman.*) The larger the proportion by which you can divide the healthier the district?—Yes.

7939. (*Dr. Stevenson.*) What is the proportion you take as the health range?—Two.

7940. The births ought to be twice as numerous as the deaths?—Yes.

7941. (*Mr. Lumley Smith.*) And having regard to the births and deaths of those four places, do you consider them healthy or unhealthy?—The general conclusion I draw with regard to some of those districts is that they are not in a very good sanitary condition.

7942. I understand your view to be that the fluctuations show that they are not healthy places?—The fluctuations show that they are not healthy places. If you take any one of the years having a high zymotic death-rate, and divide the births by the deaths, it will at once show a lower number in the unhealthy period, and corroborate the rate of mortality.

7943. (*Chairman.*) Why have you taken Grays?—Grays is the registration district which includes the districts of Grays and Thurrock, districts upon the river.

7944. (*Mr. Lumley Smith.*) Now, passing from that to another matter, in your judgment is the discharge of the sewage into the river Thames in any way likely to affect the wells in the neighbourhood?—Yes, it is.

7945. Will you tell us, if you please, what opportunity you have had of testing the effect of the sewage upon the wells. I believe you had to examine, had you not, the neighbourhood of the river with a view to sinking wells?—In 1878, when the Metropolitan Board of Works proposed to supply London with water from the chalk formation, I was engaged in making an investigation of all the sites which they had chosen for the purpose of water supply, and one of those sites was at Grays, in Essex, within half a mile of the bank of the river.

7946. How far is that below the outfalls?

[*The site was pointed out to the Commission.*]

7947. You investigated, did you not, those sites?—I investigated those sites in 1878, at least, that particular site amongst others.

7948. The Thames at that part is flowing through a chalk formation, is it not?—The Thames at that spot is flowing through the chalk.

7949. There is a well, is there not, at the Grays chalk quarries?—Yes, there are a number of wells there.

7950. Was that the place at which the Metropolitan Board of Works proposed to draw their supply?—At that site.

7951. For that purpose did you examine what the nature of the water was in the wells?—Yes. I had samples of water taken from that place, and also at Erith, and submitted to our chemist.

7952. (*Mr. Bidder.*) Where did you have samples taken at Erith?—We have had samples of water taken from the Essex Water Company's works, and from the "Green Man and Bell" well at Grays.

7953. (*Mr. Lumley Smith.*) Samples were taken at Grays, I understand?—Those wells are at Grays.

7954. Were those all that were examined?—No; those that I have just referred to were samples of water amongst other samples which have been drawn recently, in December last. But in 1878 I caused the levels of the water in all the wells in this neighbourhood to be taken, and it was found that from the pumping which was going on in those quarries at that time, and from other pumping in the neighbourhood, all the water fell to the direction of the point of exhaustion. At that point the river Thames runs through the chalk, and we found that there was a direct flow from the direction of the Thames itself (which at that point has received the metropolitan sewage) towards this spot, which was proposed to be selected for the purpose of supplying London with water.

7955. (*Sir John Coode.*) About how far is that from the direct line of the margin of the river?—The chalk quarries pumping station is a mile distant from the river.

7956. (*Chairman.*) Who was pumping there, and why were they pumping?—In order to get at the bottom of the chalk quarry, and to keep the water down it is necessary to pump, and it is found that the pumping at this particular quarry affects the water for miles round. I have ascertained most clearly that the pumping at this quarry affected some ditches a mile and a half distant from the quarry in which watercress was grown; so much so that the occupier of them, a man named Benjamin Wood, commenced proceedings against the company for compensation for the effect of their works upon these watercress beds. He commenced the proceedings.

*Mr. B. Latham, M. Inst. C.E.*

30 Jan. 1883.

(*Mr. Bidder.*) But he did not bring them to a successful issue.

(*Chairman.*) He found that there was a case of Chasemore and Richards which showed that the action was not maintainable.

(*Witness.*) Then, again, there are other quarries in the neighbourhood—there is Messrs. Gibbs' chalk quarry; it is found that when they come to pump at the quarries at Grays they can lower the water immediately in Messrs. Gibbs' quarry, which is some considerable distance from them.

7957. (*Sir John Coode.*) How far is that from them?—One mile.

7958. Do you say the effect is felt immediately?—Almost immediately; within a very short time. Then we have had the waters of these Essex waterworks and the "Green Man" well analysed, and we find that they contain very much more chlorine than was originally the case when the pumping was not going on; in fact, from a published statement made some years ago with regard to the same quarries, it was shown that the amount of chlorine was 1·4 per gallon. In the analysis made upon the 17th of September 1860 by Dundas Thompson, M.D., F.R.S., it was shown that the amount of chloride of sodium was 2·33 grains in a gallon. Now we find that the quantity of chlorine varies with the state of the tide, there being a somewhat larger quantity at high water than at low water.

7959. (*Mr. Bidder.*) What is the quantity?—The quantity is 13·6 parts of chlorine, not chloride of sodium, in 100,000 parts, the normal quantity of the district being 1·4 in 100,000 parts. From that, and using the formula which I followed out the other day, we are able to arrive at the number of volumes of river water or tidal water, for which we have the analysis of the tidal water in the Thames opposite the works. We find that there are about 20 gallons in every 1,000 of water which had come from the river, that is, at high water. On the average of all, taking the three experiments, high tide, mid tide, and low water, we have 23 gallons of river water mixed with 1,000 gallons of the normal water of the district. The testing of the well at the "Green Man and Bell" shows that there is 25 gallons of river water in 1,000 gallons. I think I ought to have said upon a former occasion that the formula I introduced for the mixing was really due to Dr. Frankland, as it was submitted to us by Dr. Frankland, and has been carefully examined to see whether it was correct or not.

7960. (*Mr. Lumley Smith.*) The result of that is that the tidal water gets into the chalk wells near the river, and if there is sewage in the tidal water that will get there also?—Yes, assuming, of course, that all the chlorine comes from the river. In the case of Grays it is difficult to see where else it could come from, as it is not a populated district where there are cesspools. There might be a doubt in the case of Erith; but in the case of Erith, a well at Crown Cottages, in Cross Street, leading out of Pier Street, Erith, contained 10·8 parts of chlorine in 100,000; that was taken at near low water, and at the same time the water in the Thames at low water contained 40·5 in 100,000 parts. That will show, compared with the low water of the Thames, that in every 1,000 gallons 322 were water coming from the river, that is, assuming all the chlorine comes from the river; that would be about a third of the whole, compared even with low water when the river is very fresh, owing to the large quantity of water coming down.

7961. (*Colonel Ewart.*) Is that taken near the inhabited part of Erith?—Yes. That was taken upon the 3rd of December 1882.

7962. (*Chairman.*) Is water containing that proportion of chlorine drinkable?—In soda water, I understand, there is a very much larger quantity than that.

7963. As I understand, judging from the chlorine it contained, one-third of the water in the well had been in the river?—That is upon the assumption that all the chlorine was due to the river. If part of the chlorine were due to the introduction of cesspool matter, that would introduce an error into it.

7964. Would not the river water have been brackish?—Not in that part of the river. But I know a town where the water contains as many grains of chlorine as the water of the river at low water did that day.

7965. But I understood you concluded, from taking a sample of the water in the well, that one-third of the water in the well had been in the river?—Comparing it with the known condition of the water opposite Erith on that particular day. There are wells upon the south coast of the country which contain that proportion of chlorine which are used for the supply of drinking water.

7966. (*Mr. Lumley Smith.*) Mr. Beaumont Morice, who has local knowledge, suggests that I should ask whether you know that any wells have been shut up?—I do not know that.

(*Mr. Bidder.*) We have a report which puts it in this way:—Cross Street; two wells; one said to be connected with cesspools; polluted.

(*Mr. Lumley Smith.*) In answer to Question 4,457 Dr. Jessett says:—"Last year we closed six or seven, "and we have closed, I suppose, every year, more or "less. I daresay we have closed six or seven wells "almost annually for four or five years past at any "rate."

7967. (*Chairman.*) Take the Grays wells. The evidence is that there is water which comes from the Thames. If water comes from the Thames it presumably contains sewage, because we know that sewage gets down there. If sewage water does come into those wells, then what next; is the water unhealthy?—It sometimes becomes, I should say, most undoubtedly so, and it has been already given in evidence to that effect.

7968. It is unpleasant to the taste, I presume?—It does not follow as a rule that it is so.

7969. Or to the smell?—Not at all as a rule. As a rule the worst waters are the most palatable; but it has been stated before this Commission that the water taken from this neighbourhood has been supplied to ships in which outbreaks of typhoid fever have occurred, and a witness made use of the expression that the source of supply needed to be investigated.

7970. Did he refer to Grays?—He did. It was Grays he alluded to as having supplied the ships in which the outbreaks of fever occurred.

7971. (*Prof. Williamson.*) Were any other constituents determined in the water except the chlorine?—No.

7972. Not the nitrates?—No.

7973. (*Dr. Stevenson.*) How long had the water been known to contain chlorine?—I know it was known in 1878. We know that in 1860 the waters were not salt, because there is a published analysis of the water of that date to which I have referred.

7974. (*Mr. Bidder.*) Where do you get the 1·4 in 1860?—It was a report made by the promoters of the water company.

7975. (*Mr. Bidder.*) Your evidence is based upon the statement that somebody in 1860, not yourself, analysed the water in a chalk well at Grays and found 1·4 of chlorine. I want to know where that is found?—I will have it referred to.

(*Mr. Beaumont Morice.*) May I mention, with regard to the wells at Erith, that one of the members of the Commission in the examination of Dr. Jessett, just before the case for the meriorialists concluded at Question 4,452, asked him this question, "Were the "cases of typhoid fever chiefly in the houses that had "tidal wells?" and he answered, "Yes, chiefly. It is "generally on account of cases of typhoid fever that "our attention has been drawn to the state of the "wells, and we have had the water analysed."

(*Chairman.*) If the well in question is near to cesspools, I do not think that becomes of so much importance.

(*Witness.*) I beg now to be allowed to draw the attention of the Commission to a Table No. 9 in

Messrs. Bidder, Hawksley, and Bazalgette's Report of 1858, in which the level of the water in the wells all the way down the valley of the Thames is given, from which you will see that there are a very large number of wells, the surface water of which is at a level below that of high tide. The levels of a number of wells at Erith are given, in which the water varies from 4 feet only to 2 feet above ordnance datum, 2 feet being the mean tide level.

(*Mr. Bidder.*) As you referred us to the page, I see the note that, "The water in the wells, although "influenced as to supply by the state of the tide, is "not brackish, the water beds in the chalk dipping "to below high water in the Thames are dammed up "during high water, and, consequently, the water "will rise in the wells," showing that there may be fluctuation in the wells without any communication with the water in the river.

7976. (*Mr. Lumley Smith.*) Now, almost the last thing I have to ask you, but which I ought to have asked you before, speaking about the solid matter which got into the river: we have heard that a certain amount of mixing goes on between what comes from the outfall and the sea water, and a certain amount of mixing goes on between what comes from the sewers and the land water. To what extent would the mixing action affect the solid matter which is not in solution, but in suspension?—The mixing action would affect everything which is capable of mixing, but it would not affect the solid matters which fall down to the bed of the river.

7977. Then, as far as the tests for mixing are concerned, would they at all show what quantity of solid matter has been deposited in the bed of the river?—No; a large quantity of solid matter clearly is deposited, and that would not be affected at all by the mixing action; that solid matter could only be carried away either by a sufficient velocity of flow in the river, or by being gradually dissolved, if it were capable of being dissolved, by decomposition, being carried away then in a soluble form.

7978. Which in your judgment would reach the sea the fastest; that which was in solution, or that which was in suspension?—Naturally everything which is capable of mixing gets to the sea very much quicker than the solid matter which lingered on the bed of the stream.

7979. As what comes down from the sewers mixes more or less with the sea water, and oscillates up and down with the tide, would it tend to deposit certain quantities of matter which were in suspension?—Yes, it would. I find that if we take the velocity flow of the sewers upon the south side, of which we know the most, that velocity flow is greater than the velocity flow of the ebb of the river itself. That is to say, assuming the sewer to be running full or half full, and the matter coming out of the sewer at a high velocity and going into the river at a slow velocity, the tendency must be for it to deposit. In the case of the north the velocity of flow in the sewers, as far as I know, is about equal to the flow of the ebb tide; they about balance each other, assuming that they are running full.

7980. I think one of the witnesses gave us the result of his experience with regard to the pace which was required to carry along suspended matter, and to prevent the solid matter sinking to the bottom; do you recollect what that was?—He gave various rates in sewers, but the rate of velocity in the southern outfall, when running full or half full, is about 194 feet per minute, and the flood tide itself is first about the same, but the ebb tide is about 160, which is about equal to the velocity in the sewers upon the north side.

7981. As the velocity slackened, would the tendency to deposit the solid matter increase?—Certainly, and especially near the turn of the tide; and in slack places the solid matter of course goes down and forms mud banks.

7982. At extreme low water and extreme high water the water would necessarily be slack at some part of the river?—Yes.

7983. (*Sir P. B. Maxwell.*) Are you referring to question and answer No. 6319?—Yes.

7984. (*Mr. Lumley Smith.*) In your judgment would the same rule apply to the sewers as would apply to the river?—It would apply to an ordinary river but not to a tidal river; the same law does not apply to a tidal river as applies to an ordinary river, but in an ordinary river the flow would carry the solid matter to the sea. Wherever there is a slack in a tidal river you would naturally have a tendency to deposit.

7985. (*Sir John Coode.*) Would not all this very much depend upon the angle at which the one would impinge upon the other?—Yes; but you may have a deep place and a deflection of the stream into the bottom which would always keep it a deep place, and then the deposit would take place in the shallower water.

7986. But two streams may meet so as to join in harmony, or they may meet at right angles?—I have in view a vertical angle, that is to say, you have exactly the same deflections in the vertical plane of an ordinary river as you have in the horizontal plane. You may have a deep hole, and the water may enter it at a considerable angle, and the consequence is that it is deflected down on to the bottom, and reflected off, and always keeps that a deep place in the river. Although the natural sectional area of the river may be so much greater at that point, yet it never silts up; the hole in the bed of the river always remains a hole.

7987. (*Chairman.*) Taking a slow flowing river, which you might think would deposit and have a level bottom, yet nevertheless you find deep holes in the bottom of it constantly?—That is so.

7988. I never could understand why it should be?—Simply that takes place in the vertical plane which takes place in every horizontal plane of a river.

7989. (*Mr. Lumley Smith.*) Have you anything to add with regard to the mixing as to the chlorine figures; have you compared at all the relative amount of chlorine at any of those places in your table which is printed at No. 7511 at high and low water with a view to this inquiry?—Yes.

7990. Have you anything to point out with regard to that?—Yes, there is a very curious point with regard to this. If you look at the amount of chlorine in the river at Barking upon this table, and the amount of chlorine in the river at St. Paul's pier, which is just about the range of the tide, you will find that upon the 14th of September, during the period of high water, there were two-thirds of the amount of chlorine in the water at St. Paul's pier that there was at Barking at low water. You must compare the high water with the low, because the water which is in the river at Barking at low water is, by tidal impulse, pushed up to the extent of the range; that which I have just mentioned was upon a spring tide. Upon the 22nd of September, it being a neap tide, you will find that the quantity is just one-third only. Then you come upon the 30th of November to a period when there is great dilution, and when the initial quantity of chlorine in the river will make a considerable difference; therefore if you deduct the 1·7, the initial amount of chlorine due to the river water, from the 5 at Barking, and deduct the 1·7 from the 2·8 at St. Paul's pier, you will see then that one-third exactly upon that neap tide is carried up to that point.

7991. The distance between those two places being, as you have said, about the range of the tide?—The distance between those two places is about the range of the tide.

7992. Although the water is pushed up from Barking to St. Paul's pier, you find a very different amount of chlorine?—Yes; you do not find all the water having gone up, or else as it goes up it mixes with the fresh water, and as it goes down it mixes with the salt water, and it is that mixing action that so much accelerates the rate of progress out of the river.

7993. I do not think you have anything to add with regard to the tables you have handed in? Have

*Mr. B. Latham, M. Inst. C.E.*

30 Jan. 1883.

you sufficiently explained them all?—There are tables on page 5 which were put in to show the amount of the mixing action going on, and on the diagram I have put before his Lordship I marked in red figures the amount of chlorine at every period according to the number upon the diagram. Upon the last occasion I put in a table, and the diagram before you shows the several quantities of chlorine. A float being put in at low water at London Stone, it floated up a certain distance, samples of water being taken both at the surface and at half the depth of the river. The next day it is put in at low water at the point where it reached the previous day at high water, and so it is carried up the river; and these tables show the amount of the admixture which goes on all the way up the river. Then following that, there is a table referring to the water coming down the river; the distance the samples are apart is shown in one of the columns, and there you see the effect of mixing with sea water as you go from the fresh water at Teddington to the London Stone again.

*The table was handed in and is as follows:—*

SAMPLES of WATER taken on TIDE flowing up the RIVER THAMES.

| Date. | Amount of Chlorine in 100,000 parts of Water at Low Water. | Amount of Chlorine in 100,000 parts of Water, at High Water after Flowing up River. | Distance apart of Samples. | Number of Volumes of Water with the least Chlorine to make one with the most. | Remarks. |
|---|---|---|---|---|---|
| 1882. | | | Miles. | | |
| Oct. 29th | 1,277·5 | 1,215·0 | 13·40 | 1·05 | London Stone to Chalk. |
| „ 30th | 241·0 | 134·5 | 14·25 | 1·79 | Chalk to Crossness. |
| „ 31st | 4·4 | 3·7 | 11·25 | 1·18 | Crossness to Limehouse. |
| Nov. 1st | 1·7 | 1·7 | 5·20 | 1·00 | Limehouse to Vauxhall. |
| „ 2nd | 1·7 | 1·7 | 3·53 | 1·00 | Vauxhall to Wandsworth. |
| „ 3rd | 1·7 | 1·7 | 1·45 | 1·00 | Wandsworth to Beverley Brook. |

SAMPLES of WATER taken on TIDE flowing down the RIVER THAMES.

| Date. | Amount of Chlorine in 100,000 parts of Water at High Water. | Amount of Chlorine in 100,000 parts of Water at Low Water after Flowing down River. | Distance apart of Samples. | Number of Volumes of Water with the least Chlorine to make one with the most. | Remarks. |
|---|---|---|---|---|---|
| | | | Miles. | | |
| Nov. 4th | 1·7 | 1·7 | 17·80 | 1·00 | Teddington to Blackfriars. |
| „ 5th | 1·8 | 3·6 | 14·00 | 2·00 | Blackfriars to Crossness. |
| „ 6th | 50·0 | 343·0 | 13·67 | 6·86 | Crossness to Medway Canal. |
| „ 7th | 1,000·5 | 1,365·0 | 14·50 | 1·36 | Medway Canal to London Stone. |

7994. I suppose this mixing brings about a better state of things than if the water went out of the sewer and did not mix?—Yes, it does; formerly the caculations were made simply for displacement.

7995. My learned friend suggested that at night-time some of the floats might have got anchored. I believe you have had the float ranges coloured so as to show which is night and which is day range?—Yes; I have had them coloured so that the black lines show the nights and the red show the days. I have had an average of them taken, and it will show that the average of that particular sheet is that the night tides are rather a longer range.

7996. (*Chairman.*) In your judgment, does the progression of the float downwards, so far as there has been any, correspond with the quantity of fresh water added from above?—You will see that in many cases the floats have gone up to a certain extent.

7997. But upon the whole?—This simply shows the tidal oscillation which is going on, that is affected by so many conditions that it does not really show the progress out to sea. I would beg leave to explain the other tables which I produce. They will speak for themselves; but in these cases you will observe that we have taken the water as if, instead of being mixed with sea water, it had been mixed with a volume of tidal or Southend water, showing the ratio of mixing all the way down the river. It does not need any further explanation, but it makes very little difference in the calculations whether you calculate from this table or from the sea-water table.

*The following tables were handed in:—*

TABLE PRODUCED from CHLORINE TESTS SHOWING the QUANTITY of UPPER RIVER (TEDDINGTON) WATER MIXED with each VOLUME of TIDAL (SOUTHEND) WATER at VARIOUS PLACES on the THAMES.

| | September 14th. | | September 22nd. | | November 30th | |
|---|---|---|---|---|---|---|
| | High Water. | Low Water. | High Water. | Low Water. | High Water. | Low Water. |
| Teddington | All river water. | All river water. | All river water. | All river water. | All river water. | All river water. |
| Chiswick | 642·0 | 9645·0 | 8587·0 | A trace of sea water. | All river water. | A trace of sea water. |
| St. Paul's Pier | 8·2 | 803·0 | 20·9 | 2518·0 | 1634·0 | A trace of sea water. |
| Deptford | 3·4 | 39·8 | 5·1 | 68·7 | 95·0 | A trace of sea water. |
| North Woolwich | 1·9 | 9·8 | 2·26 | 10·8 | 14·4 | 1634·0 |
| Barking | 1·60 | 5·1 | 1·97 | 5·8 | 10·5 | 665·0 |
| Crossness | 1·10 | 3·1 | 1·51 | 3·3 | 5·26 | 103·0 |
| Erith | 0·87 | 2·6 | 1·13 | 2·4 | 4·34 | 19·2 |
| Gravesend | 0·28 | 0·82 | 0·40 | 0·78 | — | — |
| Southend | 0 | 0·094 | 0 | 0·04 | 0 | ·13 |

TABLE PRODUCED from CHLORINE TESTS SHOWING the QUANTITY of UPPER RIVER (TEDDINGTON) WATER MIXED with each VOLUME of TIDAL (SOUTHEND) WATER at VARIOUS PLACES on the THAMES during FLOAT EXPERIMENTS.

SAMPLES of WATER taken on TIDE flowing up the RIVER THAMES.

| Date. | Volumes as above. | | Distance apart of Samples. | Remarks. |
|---|---|---|---|---|
| | Low Water. | High Water. | | |
| | | | Miles. | |
| October 29th | 0·0 | 0·05 | 13·40 | London Stone to Chalk. |
| „ 30th | 4·33 | 8·60 | 14·25 | Chalk to Crossness. |
| „ 31st | 471·0 | 637·0 | 11·25 | Crossness to Limehouse. |
| November 1st | All river water. | All river water. | 5·20 | Limehouse to Vauxhall. |
| „ 2nd | Do. | Do. | 3·53 | Vauxhall to Wandsworth. |
| „ 3rd | Do. | Do. | 1·45 | Wandsworth to Beverley Brook. |

SAMPLES of WATER taken on TIDE flowing down the RIVER THAMES.

| Date. | Volumes as above. | | Distance apart of Samples. | Remarks. |
|---|---|---|---|---|
| | High Water. | Low Water. | | |
| | | | Miles. | |
| November 4th | All river water. | All river water. | 17·80 | Teddington to Blackfriars. |
| „ 5th | Do. | 670·0 | 14·00 | Blackfriars to Crossness. |
| „ 6th | 25·4 | 2·74 | 13·67 | Crossness to Medway Canal. |
| „ 7th | 0·27 | 0·0 | 14·50 | Medway Canal to London Stone. |

(*Sir John Coode.*) If I gathered rightly the question that fell from his Lordship, it was whether or not you found the distance which the float travelled down was influenced by the quantity of fresh water in the river.

(*Chairman.*) What I meant to say was whether it corresponded to it.

7998. (*Sir John Coode.*) I think, if you look at sheet 3 of your tidal observations, you will see that it does correspond with the quantity of water flowing over Teddington Lock?—Yes; you will find that above London Bridge the amount of water has a considerable effect upon the water flowing down the river, but below it has not much effect, and when the floods come they soon begin to drive the floats down the river.

*Mr. B. Latham, M. Inst. C.E.*

30 Jan. 1883.

Adjourned to to-morrow at half-past twelve o'clock.

# EIGHTEENTH DAY.

## Wednesday, 31st January 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR P. BENSON MAXWELL.
SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANCOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.

W. POLE, Esq., F.R.S., *Secretary.*

Mr. BALDWIN LATHAM, Mem. Inst. C.E., called again; cross-examined by Mr. BIDDER.

7999. I have followed, with as much intelligence as I can, your three days of examination; but from all this mass of figures and statistics just tell me, to begin with, what conclusions do you invite the Commissioners to draw adverse to the present condition of the river?—The conclusion which I draw is that, the capacity of the sewers not being adequate for the present district, sewage is turned into the river at higher points which naturally lingers longer in the river, and at certain periods of the year tends very much to increase the pollution of the river.

8000. Granted all that, do you invite the Commission to draw a conclusion, or do you point to anything which leads to the conclusion that, as a matter of fact, the state of the river is unsatisfactory?—Certainly I do. I have already pointed out that there are conditions with regard to the water supply, and there are conditions with regard to the accumulation of mud, which in my opinion are highly detrimental to the districts below London.

8001. Granted that the conditions are adverse, do you point to any fact or observation as showing that at the present time, as a matter of fact, the condition of the river is unsatisfactory?—At the present time of course the river is extremely diluted.

8002. I do not mean at the present moment; I mean in a wider sense?—I mean generally that, under the conditions under which sewage is discharged at Barking and Crossness in the summer months, the river cannot be otherwise than most offensive and most prejudicial to the interests of those who use it.

8003. In point of fact, you put it in this way, "having pointed to certain conditions, I infer that it "cannot be otherwise than unsatisfactory"?—I have already stated in my evidence that under conditions which occur in the height of summer when this mud decomposes, and when no purification takes place, the river must be offensive.

8004. You have been engaged for a considerable time in making observations relative to this inquiry, have you not?—I have been engaged on this inquiry since June last.

8005. That being so, have you any fact or observation to lay before the Commission to show that, as a matter of fact, the condition of the river is unsatisfactory?—I have seen the river myself, on one or two occasions when I have been down it this year, simply bubbling up from the effects of fermentation, and black in colour; but I recollect a year or two ago, when I was going down in the summer, that it was very foul from Deptford to below Erith.

31 Jan. 1883.

8006. May I assume that what you saw this year was in the neighbourhood of Crossness and Barking?—It was between Barking and Erith.

8007. Was it in the neighbourhood of Crossness?—It was more or less all the way down the river.

8008. Was it in the neighbourhood of Crossness?—I say it was all the way from Barking to Erith.

8009. (*Chairman.*) Supposing you knew nothing about the river and nothing about the sewers, if we can suppose such a possibility, and you went up and down the river in a boat, would you say that there was anything wrong there?—Not at the present time; but in the summer of 1878, when I was down the river, it was certainly most frightfully offensive; it was like sailing upon the top of a cesspool, containing diluted cesspool matter.

8010. On one particular occasion?—This was in the summer time.

8011. Was the river in the same state throughout the summer?—When I was there.

8012. How often was that, do you suppose?—Upon that occasion I only went down the river and back again.

8013. (*Mr. Bidder.*) Will you just fix a little more precisely, if you can, the part of the river where you made that observation?—I have already told you that it was more or less so from Deptford to below Erith.

8014. What was the date when you made that observation?—In the summer time in 1878, probably in July, but the exact date I have forgotten.

8015. I suppose it was in relation to this water business?—I was down several times, but not down the river upon the water business; it was not upon that occasion.

8016. I will first clear away one or two minor matters to which you adverted yesterday. With regard to the question of the wells in the neighbourhood of the river, you referred to a certain well at Cross Street, Erith, yesterday, and you gave certain

*Mr. B. Latham, M. Inst. C.E.*

31 Jan. 1883.

statistics as to the amount of chlorine in it. You said, if I followed you rightly, that, assuming the chlorine came from the river, it followed that a certain portion of the well water was river water?—That is true.

8017. Having regard to the facts, do you believe that that chlorine did come from the river?—It is quite possible that it did.

8018. Having regard to the facts, do you think it did?—It is quite impossible to say for certain.

8019. Are you aware that there had been great complaints for a long time of a number of wells in Erith having been polluted by cesspools in the neighbourhood?—When I gave that evidence yesterday, I was careful to qualify it by the statement that it might be leakage from a cesspool.

8020. Were you aware that there had been great complaints of wells in Erith being polluted by cesspools in their neighbourhood?—I knew for a fact that it had been mentioned here.

8021. Were you aware, as a fact, that this particular well had been reported as having a cesspool in its immediate neighbourhood, and being polluted by it?—I heard what was read yesterday with regard to it.

8022. Now, with regard to the chalk quarry at Grays, you referred the Commission, in connexion with that, to a certain table, Table 9, in the Report of 1858, upon the main drainage, showing the level of water in wells situated in or near the line of the outfall sewers?—I referred to wells at Erith from this particular table.

8023. Now, I will ask you whether your attention was drawn to, and if so, whether you confirm the note on the right-hand side of the page. "Mr. Sturge, of "Northfleet, states that, in clearing the ground near "low water in the Thames for the foundation of a "wharf, he came upon a strong spring of fresh "water, which he walled round and preserved, and "it now furnishes a copious supply of pure water "not in the slightest degree brackish. There are "several other springs along the shore near low-"water line, all fresh water, proving that the water "bed in the chalk slopes to about the level of the "low water in the Thames." Is that in accordance with your own observation?—That is quite true with regard to the water in its natural state, but that condition is immediately altered the moment you begin to pump in the neighbourhood.

8024. I had better read the whole of the note. "At Springhead, about half a mile south of North-"fleet, near the Referees' line, the springs boil up "in numerous places to near the surface, about six "feet below Trinity high water. Mr. Sedger states "the water in his well rises and falls with the tide, "but the water is quite pure. The water in the "wells, although influenced as to supply by the state "of the tide, is not brackish; the water-beds in the "chalk, dipping to below high water in the Thames, "are dammed up during the high water, and, con-"sequently, the water will rise in the wells." Is that in accordance with your own observation?—It is. Some years ago I made a little sketch, which explains the theory of tidal wells (*exhibiting the same*).

8025. It is so, that, although the wells may fluctuate in their level with the state of the tide, it by no means follows that there is any actual transfer of water from the river in the tideway to the well?—I have known the case of a well not far from Plymouth which is absolutely dry at low water, and at high water it overflows and runs into the tidal way, being fresh water, but if any exhaustive pumping were to take place from these same fissures from which the water escapes at low water into the river, the tidal water would enter.

8026. But, speaking of the chalk in the London basin, that is fed from high lands both north and south, is it not?—It is fed from high lands upon the south as regards one portion, and a portion upon the north is clearly fed from high lands upon the Essex side.

8027. And the subterranean flow of the water is from those high ridges towards the bottom of the valley in the river?—That is so; but it is known that the quantity of water varies immensely, coming down in the chalk formation from year to year. The moment you begin to pump, you alter the whole conditions, and you may have water flowing back through the apertures by which the water escapes at ordinary times.

8028. And with regard to your observations at this particular chalk quarry at Grays, you said that you had got some observations of the year 1860, and you were kind enough to say that you would give us the reference to them.

*The Report was handed in, and is as follows:—*

"REPORT ON THE WATER FROM THE SPRINGS AT GRAYS, ESSEX.

"I visited Grays on the 30th August, in company with Mr. Meeson and Mr. Beale, jun., and had an opportunity of examining the copious springs originating from the chalk of that locality. The water was perfectly pellucid, and possessed a sparkling aspect. Its taste was most agreeable and refreshing. The temperature obtained by immersing a thermometer in one of the springs as it flowed from the chalk was 53° 5″; the mean temperature of the atmosphere accurately ascertained being at London 61° 4″. This characteristic would be most valuable should the water be supplied to London, since a difference of temperature of eight degrees between the air and the water would be extremely grateful to the palate, and would afford a strikingly favourable contrast with water derived from rivers, which, in this latitude, have an average temperature above that of the atmosphere. After being kept for a fortnight the water exhibited no disposition to deposit any sediment and no appearance of vegetable growths, as frequently occurs with river water when allowed to stagnate. I could detect no traces of animal life in the water, whereas in river waters, even after filtration, the absence of evidence of animal life can rarely be affirmed.

"I have carefully tested for the presence of organic matter, and have only been able to detect a trace, but in such minute quantities as to render it impossible to assign any weight to this constituent. The water having been taken at the end of an unusually wet month, when water is most likely to be contaminated with organic matter from the surface by impregnation from rain, falling on cultivated soil, I think it very probable that under usual circumstances there may be no organic matter at all in solution, except in a condition of oxidation, and, therefore, comparatively innoxious in a sanitary point of view. When subjected to quantitative analysis it yielded the following composition—per imperial gallon—in grains:—

| | |
|---|---|
| Volatile matter - - | 1·60 |
| Silica - - - | 1·60 |
| Sulphate of Potash - | 1·30 |
| Sulphate of Lime - | ·95 |
| Carbonate of Magnesia - | ·96 |
| Carbonate of Lime - | 16·13 |
| Carbonate of Soda - | ·30 |
| Nitrate of Lime - - | 1·23 |
| Chloride of Sodium - | 2·33 |
| | 26·40 grns. per gal. |

The chalk present in solution gives the water 16·13 degrees of hardness, which could be removed by the liming process of Dr. Clark. The small amount of sulphate of lime dissolved in the water, compared with that in the waters at present supplied to the metropolis, would render it an exceedingly soft water if treated by the softening process referred to. But, taking the water as it now issues from the chalk at Grays, I consider it well adapted for the domestic

supply of the metropolis, and superior in a sanitary point of view to waters obtained from rivers and open canals.

"ROBERT DUNDAS THOMSON,
M.D., F.R.S.S., L. & E.
Court House, St. Marylebone,
17th September 1860."

8029. This, as you said yesterday, shows that in 1860 that gentleman reported having found 2½ grains of chloride of sodium, you say that your analysis found 13½ parts of chlorine?—Yes, at high water; that is 13·6 in 100,000 parts. This paper gives the figures in grains per gallon.

8030. Are you aware that 13 parts of chlorine in 100,000 parts is by no means an unusual proportion in fair chalk water?—A most unusual thing.

8031. You are prepared to say that, are you?—I am prepared to say that most distinctly, from my knowledge, with regard to the chalk formation in which I have been making special observations for seven years.

8032. Will you produce for me the analysis which you had taken, and which showed those 13 parts of chlorine?—I think the chemists had better produce their own analyses.

8033. It will be produced?—It will be produced.

8034. By whom was it made?—By Professor Way, these tests were made; but Dr. Tidy has analysed the water in the neighbourhood, and he will be able to speak to it as well, as he was engaged upon the water question.

8035. (*Chairman.*) Had your analysis of the chalk water been limited to what, I believe, are called the waters of the North Downs?—No; I have generally collected statistics both from the North Downs and from the South Downs, and in the case of the chalk in the neighbourhood of Hull, in Yorkshire.

8036. And you find that 13 in 1000,00 parts is a large proportion?—Except where it is near the sea, and, as I said yesterday, there are wells near the sea which contain a very much larger quantity, but for inland wells it is an enormous quantity.

8037. (*Mr. Bidder.*) I will tell you what I want to put to you at once; was there in that analysis any evidence of sewage contamination?—I believe that the samples were only taken for the purpose of ascertaining the quantity of chlorine, for my own instruction, for the purpose of working out the relative volumes according to the formula which has been introduced, and the analyses only show the amount of chlorine in 100,000 parts.

8038. Now, passing on to your evidence of yesterday, you made an observation with regard to the sewage having a tendency to deposit whatever solid matter was in suspension as the velocity diminished? Yes, certainly.

8039. In point of fact, is not the sewage brought to absolute stagnation in the reservoir at the outfall?—Part of it is.

8040. The bulk of it; of course, there may be a certain quantity which happens to run through just at the time when the outfalls are opened, but as regards the bulk of it, it is brought to a condition of absolute rest?—You cannot say absolute rest, it would be to a slight extent stirred up by water flowing into it, but still to a great extent it will be in a state of comparative quiescence where there is no direct flow.

8041. Therefore the matter which has been upborne by the velocity of the stream, and is ready to fall as soon as the velocity ceases, has an ample opportunity of doing so in the reservoirs themselves?—Yes, and I find, in reference to one of the earlier reports, I think it is one of the 20th of July 1858, of Messrs. Bidder, Hawksley, and Bazalgette, that they point out that the reservoirs are purposely to be used as reservoirs of subsidence, so that the matter might accumulate at the bottom and not flow into the river in times of storms.

8042. In connexion with this matter, you gave certain figures yesterday as regards the amount of solid matter that comes out of the sewage in the year, and you quoted that report as to a certain extent confirmatory; I think it was at page 74?—Yes, it was 250 tons a day.

8043. I suppose you were referring, when you mentioned 250 tons, to that passage at page 74; let me read the whole passage in order that you may have it all before you. "In considering the causes "of the turbidity of the Thames, it should be remem- "bered that the amount of solid matter of every "description which is poured into the Thames by "the London sewers is a comparatively insignificant "quantity, certainly not greater than 250 tons a day, "a quantity scarcely exceeding that which is cleared "out of the docks by manual labour only. The mud "incident to the Thames as a tidal estuary is largely "in excess of the mud projected into the Thames by "any population on its banks; the former is per- "manent, whilst the latter is perpetually undergoing "destructive decomposition." Now, do you agree with that? There are two assertions there, one that, supposing it is 250 tons a day, it is quite insignificant compared to the mud which is due to the Thames as a tidal estuary; and the other that, whatever its amount, it is perpetually undergoing destructive decomposition?—I say that a certain portion of the solid matter cannot undergo a destructive decomposition.

8044. First, let us take it that it is insignificant in proportion to the mud naturally due to the Thames as a tidal estuary; what do you say to that?—I look upon the mud which is brought up by the flow of the tide as being the same pretty well every day, simply passing backwards and forwards by the flow of the tide, but in the case of sewage it is a fresh volume added every day.

8045. Is it not the fact that the passage of the tide, the action of the in-flowing tide, the waves produced by the wind and by steamers, and so on, are constantly abrading soil from the banks of the Thames?—Yes, exactly; that matter is partly made up of the solid matter which has gone in as sewage.

8046. Not that which is part of the solid banks of the Thames?—I am speaking generally of the mud.

8047. Then is it not the fact that a large quantity of mud comes down by the upland water?—There is a certain quantity, but very small comparatively, which discolours the water. For instance, if you go up the river to-day, you will find that it has a peculiar milky brownish appearance, but that amount is insignificant compared to the total matter.

8048. Do you agree or not with the assertion that the amount of solid matter introduced by sewage is insignificant compared to that which is introduced by natural causes?—I cannot say that it is insignificant.

8049. (*Chairman.*) That is rather an awkward word; it might be insignificant in point of bulk, but not in point of effect. I suppose that one grain of arsenic might be insignificant in point of bulk.

8050. (*Mr. Bidder.*) I am at present only on the point of quantity?—I say that in course of time this mass of mud which is passed into the river from the sewage accumulates to an enormous extent, and therefore it cannot be looked upon as insignificant as regards its effects upon the character of the river itself.

8051. Never mind its effects; do you agree for the moment in the fact that it is insignificant in quantity; is it insignificant in quantity?—If you take the whole quantity in a particular day in the whole of the Thames, and the mud in suspension of all sorts, and compare that which comes in on that same day with what comes in from the sewers, of course the latter bears a very small proportion to the whole.

8052. I do not wish you to limit your answer to a particular day, but, taking the whole year round, taking the quantity produced by the sewers, and the quantity produced and added by natural causes, is not the amount of sewage of insignificant quantity?—No,

*Mr. B. Latham, M. Inst. C.E.*

31 Jan. 1883.

it is not, because in the case of natural mud it is the same mud moving backwards and forwards, whereas in the case of sewage it is fresh mud brought in every day.

8053. (*Chairman.*) But there is fresh mud introduced every day by natural causes?—Not much, except in times of flood.

8054. And the amount of mud produced by the wash of the steamers and so on?—That is all the same mud reproduced.

8055. If you were to dip your vessel into the river in an average condition, what proportion of mud other than sewage would there be to sewage mud?—I think the chemists can answer that question better than I can.

8056. I should say not?—It would require a chemical analysis to determine this question.

8057. I thought you had given us the amount of solid matter that flowed into the river?—Yes, I have.

8058. I should have thought that you would have known what proportion of natural mud there would be in ordinary water?—I do not know what amount of suspended matter there was in the river upon these particular days throughout the river, but our chemist would know.

8059. (*Mr. Bidder.*) Has your attention been drawn to the observations which were taken, I believe jointly, by the late Mr. Keates and Dr. Tidy, who was upon your side of the table upon the last inquiry, the mud inquiry, which are printed in the volume the Commissioners have before them; it is in the tables before page 1176?—I have not seen anything in that inquiry relating to chemical analysis.

8060. This is not as to chemical analysis; but as to the tons of mud that come over Teddington Weir, there is a series of tables, and the particular table to which I am now referring is Table C. I draw your attention to certain observations in the month of February 1880, showing an average of 445 tons a day?—I observe that this is in a particular month only, namely February 1880, a month of course when there would be much more likely to be floods than in other periods of the year, and, therefore, much more likely for suspended matter to be going down, when it is, as shown to be, 444·9 tons upon the average of that month.

8061. (*Chairman.*) That is a wet month?—It used to be called February fill-ditch when I was a boy. I should like to point out to you upon that table that upon one occasion it is as low as 5·8, and upon another day it is 4666·2 tons per diem.

8062. (*Mr. Bidder.*) You say that that is a month of flood, but I want to draw his Lordship's attention to what the arbitrators say at page 22 of their Report at the end of the volume. They say, "The Thames is a "comparatively clear stream except in time of flood," that is of course the Upper Thames. "On the "other hand, a series of observations was specially "made during the month of February 1880; the "samples of water, instead of being collected one "foot below the surface, were taken daily as nearly "as possible at the mid-depth of the river. One "sample taken, when the flow past Seething Wells "was at the rate of 81,000,000 cubic feet per 24 "hours, showed the total solid matter in suspension "to be as little as six tons in 24 hours; but a sample "similarly taken when the flow had increased "sixfold in consequence of rain showed that the "volume of solid matter amounted to 4,666 tons in "the same interval of time. It is to be regretted "that a large flood did not occur during this month, "and that we have been unable to obtain evidence of "the amount of matter in suspension brought down "by the upland waters of the Thames under such "circumstances," so that it was not a month of exceptional flooding?—No, but you will see quite clearly from this table that the ground was excessively sensitive, as is shown by the marked fluctuations from day to day in the quantity of solid matter coming down, that is, sensitive to the rain flowing off.

8063. Now they go on to say, speaking of the foreshore and saltings, "The tidal estuary of the Thames "is stated to be about 70 miles in length, in which "about two-thirds of the foreshores are protected "from the wash of the water. The tidal tributaries, "including the Medway, appear to be of about the "same length, but of the proportion of protected "foreshores in these no evidence was given. The "saltings are portions of the foreshore which are "comparatively level, covered with vegetation, and "overflowed at high water for the most part only at "spring tides. The wash of the river, especially "that caused by winds and by steamers, disintegrates "the sides of the saltings. The balance of loss which "the river banks and saltings in the Thames have "suffered was estimated to be 766,000 cubic yards in "the whole period since the outfalls were opened, to "which an addition of 90,000 cubic yards were esti-"mated as contributed by the tidal creeks; this would "afford somewhat less than 400 tons a year for each "mile of foreshore." Have you any observation of your own to make upon that point?—Taking the outfalls to have been opened in 1864, and the inquiry was in 1878, that is 14 years, and only 766,000 cubic yards in the whole period were washed in, divide that by 14, and it shows a very much less quantity of matter annually washed from the saltings than that which comes from the sewers.

(*Chairman.*) It is about a fourth part, is it not?

(*Mr. Bidder.*) The Commissioners performed the calculation and made it 400 tons a year for each mile of foreshore, that is 56,000 tons a year.

(*Witness.*) It is less than a third of the total quantity, as I have shown, brought in by the sewers, calculated upon the basis of the ABC process.

8064. But it is 400 tons per year per mile of foreshore?—I have told you that the amount of solid matter brought in by the sewage as shown by ABC experiment is about 200,000 tons a year, that is nearly four times this. I will give you the right number, it is 54,714 tons a year from these saltings, that is, taking 14 years.

8065. That looks like a good deal more than a third of your 250 tons a day?—But I did not give the 250 tons a day.

8066. The next thing that the arbitrators point out is the denudation of the bed of the river as supplying materials, do you agree with that?—I should think it is a very difficult thing in the Thames to decide what has been taking place from natural denudation, and what has been taking place from the dredging which is constantly going on.

8067. Then at page 23 the arbitrators point out that "A proportion of suspended matter is beaten up "in storms from the sand and mud banks at the "mouth of the river, and is carried along by the "in-flowing tide, as is the case in all tidal estuaries," do you agree with that?—It is quite possible at certain periods, but you must remember this, that it can only be carried 12 miles up the river.

8068. Then at the same page they say, "the dry "weather sewage contains on an average 23 grains "per gallon of suspended matter;" how is that to be reconciled with your 57?—I say that is utterly fallacious. I have looked at those reports, and I find that there is an enormous discrepancy in them.

8069. You are aware that this is the report of the arbitrators after a long and careful inquiry into the analyses produced by chemists; it is rather a strong thing to say that it is utterly fallacious?—I say it most distinctly, having a very good knowledge of what the solid matter in sewage is. I say these tables given by the chemist to the Metropolitan Board of Works show that in the north of the Thames it is 25½ grains, and in the south it is 21½ grains. Now, as we know that even in dry weather the sewage upon the south is mixed with 50 gallons of water per head per day, and the sewage upon the north with 30 gallons per head per day, those two proportions of solid matter bear no such relation to each other, as the relative volumes show. If the south is right, the north

ought to have shown a very much larger proportion of suspended matter. We know that a very large amount of suspended matter rolls down the bed of the sewer and escapes collection in small samples.

8070. You say the conclusion of these gentlemen is utterly fallacious upon this point?—Whatever their conclusion is, I differ entirely from them.

8071. The ground for your own conclusion, I understand, is a certain ABC experiment, which you referred to, which was carried on at Crossness; that is the only one you favoured us with?—I gave you the three modes in which it was arrived at.

8072. You said that that was an experiment conducted by the late Mr. Keates, the chemist of the Metropolitan Board of Works, who unfortunately died a few months ago?—The experiment was conducted under the supervision of Mr. Keates.

8073. You yourself are not a chemist?—I am not.

8074. I will ask you to turn to page 961 of this Mud Inquiry volume, and I will draw your attention to Mr. Keates' own evidence. At the bottom of page 961 you find Question 10,080; the result is given. "That would reduce it to 26 grains," and the answer is "To about 26 grains." Now I invite your attention to this. The very gentleman who conducted the experiment says that the result of that experiment is not 57 grains, but 26?—I see that they have taken pretty well my own figures, but unfortunately they have not shown any determination as to the difference between the matter in solution in the sewage and in the effluent water; a part of the chemicals went away in solution in the effluent water.

8075. He did not know his business any better than the arbitrators?—I have given you his figures from his report, which show clearly that the quantity of suspended matter in this experiment was what I have stated, namely, 57 grains in the gallon.

8076. (*Chairman.*) Do you say that this experiment was not satisfactorily conducted by him?—The experiment was quite satisfactory, but the conclusions in the Mud Inquiry Report do not agree with the statements in the evidence. There was a certain amount of matter added to the sewage which went away in solution in the effluent; that is to say, the effluent contained a greater amount of matter in solution than the sewage originally did, and that ought to have been deducted.

8077. In their calculations they begin by adding the solid matter; that they do add, and then they omit to deduct that which went away in effluent?—Yes.

8078. That is your proposition?—Yes, those are the exact figures here.

(*Mr. Bidder.*) I thought it fair to draw the witness's attention to the fact that the gentleman who made the experiment had arrived at a different conclusion.

8079. (*Chairman.*) Does it appear in this evidence that any deduction had been made for the solid matter carried away in the effluent water?—That does not appear.

8080. And you say that some such deduction ought to have been made?—Certainly.

(*Chairman to Mr. Bidder.*) Do you say that it does appear that there was such a deduction?

8081. (*Mr. Bidder.*) I was going to ask a preliminary question. (*To the witness.*) Where does it appear that there was an increase of the matter in solution?—I have here a report of Mr. Keates, and on page 16 he gives the analysis of all samples of the sewage between August the 15th and the 30th of November; and the total solids in solution, if added up, and the average taken, show them to be 72 grains, and then the effluent water analyses are given by himself as 98·7. That is in the table on page 10 of the same Report, in the first column.

8082. (*Mr. Bidder.*) Where did you get the 72 grains?—At page 16 of Mr. Keates's report. By adding up all the solids in solution, and dividing the result by all the examples given there, it comes to 72.

8083. It is suggested to me that there were great variations, as the analyses show, in the quantities of the solids in solution, and that the figures you relied upon in the one case, do not relate to the same occasions as the figures you compare with them in the other case?—I presume Mr. Keates, in his report to the Metropolitan Board of Works, supplied this table showing what was the constituent of the raw sewage, and what was the constituent of the effluent, so I presume that he considered it a fair result to arrive at what was the effect of this process in the sewage.

(*Mr. Bidder.*) Let me refer your Lordship to the last page of the Report which the witness is referring to, which contains the analysis of raw sewage; your Lordship will see it gives about a dozen days, and the dates are given; this is on page 16, the last page of Mr. Keates's Report.

(*Witness.*) That column adds up to 864·4, and the average is 72.

8084. (*Mr. Bidder.*) Your Lordship will see that the analysis of raw sewage relates to about 12 occasions, the dates of which are given, beginning with August the 15th, and ending with November the 30th; the analysis of effluent sewage to compare with it will be found in the two previous pages, 14 and 15. Now, the first thing that these figures show is that the amount of solids in solutions varies very much?—It does.

8085. You have taken the effluents upon one day; at page 14 it is 90; it sinks to 79, and it rises to 145; that is enough to show a great amount of variation. Now, upon August the 15th we have not the corresponding analysis of the effluent water, therefore we cannot compare that. But upon August the 28th we have the amount of solids in solution as 74·9 in the raw sewage, and 90·3 in the effluent water?—Yes, showing the effluent water as containing the greater quantity.

8086. There is a difference there in favour of the effluent water, but nothing like so great as that which you mentioned; in fact, it is about 15 grains instead of 28. Now, on September the 9th we have the raw sewage, but we have not the effluent water. On September the 14th we have the raw sewage, but not the effluent water; upon October the 15th we have both.

(*Chairman.*) It does appear that the total solid matter in solution in the effluent water was greater than in the sewage.

(*Mr. Bidder.*) It does; I believe the chemists will agree that there is a certain excess, but not anything like what the witness has suggested.

(*Witness.*) I have only taken the figures from the Report.

8087. (*Mr. Bidder.*) I venture to suggest that you have compared things which are not comparable; you have compared raw sewage on one day with effluent on another day?—But, from what I understand from these experiments, the sewage was averaged, and Mr. Keates, in publishing these tables, gave what he considered to be the average quality of the sewage itself, and the same with regard to the effluent water; therefore, I consider that, if I take his results as I have done, it fairly gives these figures which I have already produced to the Commission.

(*Sir John Coode.*) Are those the experiments upon which Mr. Keates made the remark that the sewage at the southern outfall was abnormally weak throughout the whole experiment. I find that at page 10. If that relates to the same experiment, it would have a material bearing upon the point in question.

(*Mr. Bidder.*) The sewage upon the south side is always weaker than upon the north.

(*Sir John Coode.*) But Mr. Keates says, "With "respect to this point the sewage upon the south "side was abnormally weak throughout the whole "experiment," which would have a material bearing.

(*Witness.*) And at other times the amount of solid matter in solution would be very much more.

8088. (*Mr. Bidder.*) Let me now go to the other

*Mr. B. Latham, M. Inst. C.E.*

31 Jan. 1883

*Mr. B. Latham, M. Inst. C.E.*

31 Jan. 1883.

branch of the statement of the Referees in 1858 that the matter in suspension in the sewage is subject to a constant destructive decomposition; do you agree with that?—Yes, a certain portion of it; as I mentioned yesterday.

8089. To a very great extent that is true, is it not?—The chemists will tell you that.

8090. Suppose your figures which you gave yesterday were right, and that roundly 200,000 tons of suspended matter were annually projected into the river by the outfalls, have you any idea how much of that matter would be burnt up and destroyed by the destructive decomposition?—No; that is a matter beyond my province.

8091. You refer me to the chemists?—I do.

(*Sir John Coode.*) Let me refer you to page 125 of Messrs. Hawksley, Bidder, and Bazalgette's Report, on which is Table 13, in which you will see the extent to which the suspended matter varies according to the period of the day at which the sample was taken. Table 13 in Messrs. Hawksley, Bidder, and Bazalgette's Report shows that the total suspended matter from the samples taken at noon was 38·15 grains. Then, if you turn to Table 14, the samples of which were taken at midnight, you will see that the suspended matter scarcely touches 14 grains per gallon.

(*Mr. Michael.*) That is, giving the average between the samples.

(*Sir John Coode.*) But you must take care that the samples always are averaged.

(*Mr. Bidder.*) It must be remembered, in referring back to these tables, that in the sewers which are referred to there the sewage was much stronger than in the Metropolitan outfalls.

(*Sir John Coode.*) My remark only went to this, that we must have averaged results taken over periods of the day.

(*Mr. Bidder.*) I think you will find very valuable results in the Arbitrator's Report, and in the evidence in that book which is upon the table, because the subject was gone into in extreme minuteness on that occasion.

8092. (*Chairman.*) What is this destructive process which is referred to. It is not annihilation of the matter, but the resolution of it into its constituents?—Certainly, all the organic matter is capable of being oxidised and changed into different forms, carbonic acid, nitric acid, and so on.

8093. Changed into its constituents, it would be no longer solid then?—No, it would be changed and go away in the water.

8094. It would be no longer capable of depositing itself?—That part which is mineral, such as the road detritus, would be capable of forming sand in the bed of the river.

8095. Would the strictly organic matter, though no longer capable of depositing, be capable of poisoning the water?—Yes, it is that which in hot weather really causes the water and the mud-banks to be so offensive. In the course of decomposition, certain parts of the constituents of the mud-banks are given off in a gaseous form and pass into the water.

8096. (*Mr. Bidder.*) And as matter in suspension ceases to exist?—I was speaking of the mud-bank, which was not matter in suspension.

8097. However, you refer me to the chemists as to what matter disappears as matter in suspension?—Yes, I have not myself made any experiments in the Thames mud, but I know that the chemists have, both upon your side and upon our side; therefore they are the competent parties to speak to it.

8098. You gave a confirmatory calculation yesterday, based upon the assumption that every unit of the population produced, I think you said, 3½ ounces per diem of solid matter contributed to the sewage?—Yes.

8099. Are you aware that that 3½ ounces,—I do not know where you got it from; it is not a recognized figure—represents moist fæces and not dry fæces?—I beg your pardon, it does not at all.

8100. I am told so by a chemist; is it not the fact that that figure represents matter which contains 75 per cent. of water?—No, certainly not.

(*Dr. de Chaumont.*) I put that question to Mr. Latham yesterday, and he distinctly says it represents water-free substance.

(*Witness.*) I stated also that that included the total matter in solution, both in the urine and fæces.

8101. (*Mr. Bidder.*) Your calculation is based upon the assumption that there is that amount of solid water-free matter?—Upon the understanding that that amount in solution was made up by other substances which were added to the sewage.

8102. That is another point; but your basis of calculation is founded first upon this, that each unit of the population contributes in suspension and solution what is equivalent to 3½ ounces of solid water-free matter?—Yes, but with no view of saying that that contains nothing that was not suspended matter in the sewage.

8103. (*Chairman.*) Take the excreta of a man for a day, and dry it thoroughly, so that there was no moisture in it, would that be 3½ ounces?—The excreta and the urine, taking the average of the whole population. But, taking a man alone, it would be more. A man's excreta upon the whole would, it is calculated, amount to one quarter of a pound of fæces in a moist state.

8104. Not including the urine in that case?—No.

8105. Is there solid matter in the urine when it is dried?—Yes.

8106. (*Mr. Bidder.*) I want to see if we correctly understand the basis. You mean that if the entire excreta of a man had all the water evaporated from them they would weigh 3½ ounces?—I do not say of a man; I say the whole of a mixed population, men, children, and women, more or less.

8107. That is your basis; that the entire excreta of an average unit of the population, when evaporated, so that they would contain no moisture, would weigh upon the average 3½ ounces?—Yes.

8108. Passing from that to the inference with regard to the amount of suspended matter, before you can apply that in any way to the amount of the suspended matter in the sewage, you must have some knowledge as to the proportion of that 3½ ounces which would represent matter in suspension and matter in solution originally?—Yes.

8109. Have you any information to give to the Commission as to that point?—I do not think I have the figures; but in one of the reports of the Commissioners you will find them fully set out. Those are of course things which I do not know from actual experiment, it is only a matter which I have become acquainted with in the course of my profession; but from the same source from which I have got it I can provide you with the quantity.

8110. Have you made any assumption upon that quantity in your calculation?—I have already said that I base nothing whatever upon that fact.

8111. Suppose, for instance, the fact be, as I am told it is, that of the total solids obtained in that way, whether it is 3½ ounces or any other quantity, four-fifths represents the matter in solution and one-fifth represents the matter in suspension; does not that very seriously affect the amount of matter in suspension that you get?—Of course, if that is so.

8112. If that is so, would it not seriously affect the question?—But it is nothing like that; there is four-fifths of the total nitrogen in the urine in solution, but that would not be true with regard to the solids.

8113. Where did you get your 3½ ounces from; of course, as an engineer, it is not from your own observation?—I cannot tell you, it is information which I have come across.

8114. You cannot refer me to any documentary authority on that point?—In a great number of places I believe it is quoted; it is in the Report of Mr. Cuthbert Johnson to the Commissioners of

Sewers; then there was the evidence given before the Select Committee of 1858, when Dr. Thompson went very largely into that question. I have a note to this effect—"Report of Select Committee on River "Thames, July 1858, Evidence of Dr. L. Thompson, "Question 1691. Each individual contributes at the "rate of 3½ ounces per diem."

8115. But contributes what?—Solid matter.

(*Chairman to Mr. Bidder.*) I have no doubt it is subject to correction and better information, but, in the opinion of one member of the Commission, that is about the contribution of each average individual.

(*Mr. Bidder.*) I am told that that is about the contribution of moist fœces, of which 75 per cent. is water; but I think it would be a saving of time if I were to leave that till the chemists come into the box. Mr. Latham says it is not an observation of his own, and, having got what his observation is, I will leave it there.

(*Witness.*) I find that the same eminent chemist, Dr. L. Thompson, in the same inquiry, estimated the solid matter of the sewage then at 260 tons a day; that is at Question 1671.

(*Mr. Bidder.*) I will pass from that I have got clearly from you what your basis is, and I shall not profitably occupy time by carrying it further. It comes to this, as far as you are concerned, that your figures are taken upon a basis, and you have explained to us that you do not undertake to say what the proportion of sewage destroyed as matter in suspension by decomposition is. Beyond that, have you any knowledge of your own of what the proportion is between what is dry and what is moist?

(*Sir P. Benson Maxwell.*) I understood the witness to say that he gave you certain results from the Native Guano Company's experiments, and then he said, if you will assume that 3½ ounces is the ordinary amount that is generally recognized by men of science, then you will find that my calculation from the Native Guano Company's process is very much confirmed by the calculations upon that estimate.

(*Mr. Bidder.*) My question is whether it does confirm it or not; and that depends upon whether it is dry or moist, or a mixture of the two.

(*Chairman.*) The calculations of the men of science show what ought to be the result of the experiment, and the result of the experiment was that.

(*Mr. Bidder.*) But there is also a question behind; supposing the figures are right in the beginning, how much of that, or what proportion, is destroyed by chemical decomposition?

(*Chairman.*) Made to cease to exist as organic matter?

(*Mr. Bidder.*) No, as matter in suspension; that it becomes soluble matter, or gas.

(*Witness.*) I gave another estimate of the amount of solid matter which is drawn from the experiments which I mentioned as being made at Croydon, and that was, that it was one-fifth of a pound per head per day. The 3½ ounces does mean matter in suspension, but is only given as a matter of comparison with the figures I gave from the ABC experiment, and also to compare with the one-fifth of a pound per head, which, I say, is a very fair estimate of the amount of solid matter contributed by the population to the sewers.

8116. (*Mr. Bidder.*) Now, passing from that, you told me that 13 grains of chlorine was an unusual amount of chlorine to find in chalk water, upon the average?—I said in an inland place.

8117. I draw your attention to the Sixth Report of the Rivers Pollution Commission of 1874, and on page 104 of that Report is a Table in which they give the composition of water in deep wells in the chalk beneath the London clay, and they give an analysis of the water in wells in different parts of the country, and they give the quantity of the chlorine, and they show an average of 15, which is rather more than yours. Taking those results, it would show that your well at Grays was rather freer of chlorine than the average of the unpolluted water of the district?—I should like to say, with regard to that, that those you are referring to are a totally different character of water from those of ordinary chalk wells; in every one of those instances the chalk is overlaid by other geological formations, and, whenever that is the case, it makes a very considerable difference to the quality of the water. But if you go to absolute chalk wells where there is no other geological formation except the chalk or the Thanet sand overlying it, then I say that, with the exception of places liable to be infected by sea-water or tidal water, you will not find such a quantity of chlorine in any instance.

8118. But at Grays that chalk is fed by water from chalk hills, north and south, a great many miles of which are overlaid by that stratification?—Let me point this out, having studied this area very carefully. I find at New Wimbledon a bore-hole mentioned. Now it is a fact that the chalk in that district is absolutely devoid of water; the water comes from the Thanet sand and the Woolwich and Reading beds overlying the chalk, and by infiltration from the Wandle itself. I can show you that all the wells in the district of the Wandle valley are supplied by waters that infiltrate, and are not the natural water of the district itself.

8119. But you know the Wandle itself is chalk water?—Yes; but I know that the Wandle and the waters which are supplied from the strata overlying the chalk are not so pure as the real chalk water.

8120. But in this Report they give this as a fair example of unpolluted waters from deep wells from chalk beneath the London clay?—Yes; but I say that it has been investigated over and over again by chemists and found that whenever the chalk is covered by London clay, the water differs essentially from the pure chalk water.

8121. But the London clay, if I am not mistaken, though it may not overlie the Grays quarries, yet overlies the district all round. Let me now draw your attention to the fact that the very worst well in this list is the well at Braintree, in Essex?—Yes, it is a very deep well, and a very deep well under those conditions which I have already pointed out, so that the water differs essentially from the chalk water in these wells.

8122. Am I not right in this, that the London clay overlies the chalk in that part of the river?—In the case of Braintree there is a considerable depth of clay overlying the chalk.

8123. Will you kindly follow my question? Am I not right in saying that in the district in Essex, in the neighbourhood of Grays to the north, the London clay overlies the chalk?—Yes, certainly, in part of it.

8124. And within less than a mile of the well itself?—I cannot say that, but you had Mr. Whitaker here, and he told you the exact geological formation of the district. I may say that there is a list of chalk wells at page 132 of the Sixth Report of the Rivers Pollution Commission, and there is not one of them which has the amount of chlorine which is shown by the Grays water, and the waters at Grays, before being exhaustively pumped, yielded a very small amount of chlorine.

8125. Now, going on to another matter. You gave a good deal of evidence about the design of the Metropolitan main sewers, and as to what they were provided for as compared to what they have to do. I will not attempt to follow it out in detail, but I will ask you one or two principal matters. You said that the western district was not intended to be provided for by these sewers, and was afterwards taken in; that was the purport of your evidence?—I read paragraphs from several Reports of the Metropolitan Board of Works, showing to my mind that that was the case.

8126. Are you aware that the sewers were afterwards enlarged distinctly to accommodate the western district?—I have already distinctly pointed out that it could not be so, because from the dates of the Reports the northern outfall was more than half completed at a time when the Metropolitan Board of

*Mr. B. Latham, M. Inst. C.E.*

31 Jan. 1883.

Works had not determined to take the sewage of the western district to Barking; it is quite clear that the low-level sewer was enlarged from 9 feet to 10 feet 3, but not the northern outfall.

(*Chairman.*) This is a matter upon which there can be no doubt; it is not a matter of opinion. Sir Joseph Bazalgette can tell us how it was. If he does say that they were enlarged, then your speculations are erroneous.

(*Witness.*) Then the Metropolitan Board of Works' Reports are erroneous, for I am taking my statement from the actual Reports published by them.

(*Mr. Bidder.*) My learned friend and myself thought it would be better not to follow all that part of the witness's evidence out in detail, but let Sir Joseph Bazalgette deal with it when he comes before you.

(*Mr. Lumley Smith.*) It is convenient for my learned friend to indicate the matters upon which he will contest our evidence.

(*Chairman.*) This is scarcely a matter of opinion. All that you are called upon to do is this; Sir Joseph Bazalgette will say you are wrong in your conclusion. In the face of that, are you prepared to abide by it?

8127. (*Mr. Bidder to the witness.*) In regard to the population, are you aware that you have made a mistake in the population, and that you have counted part of it twice over?—Which part.

8128. I will refer you to it

(*Chairman.*) That is a point which you ought to go into and show which part.

8129. (*Mr. Bidder.*) I cannot lay my hand upon it at the moment, but let me ask you in the meanwhile another question upon the deductions drawn from the Croydon observations. Besides the observation I threw out at the time as to what happens upon a particular spot not happening upon the whole area at the same time, is not there this element also in comparing a great area with a small one; that, even where you have a certain amount of rainfall over a whole area, where it is a very large area the distances of certain parts of the area from the outfall are so different that the flow is spread over a longer time. In the case of London, for example, the eastern part of London is within three or four miles of Barking, while the western extremity of the district is more like 16 or 17 miles, and consequently, supposing you have a shower over the whole district at once of a tenth of an inch, the eastern part has been got rid of long before the western part comes upon the back of the sewer: is not that true?—Yes, that is so; but I have only dealt with the figures you have given us with regard to the carrying capacity of the sewers.

8130. Supposing that at Croydon you observe that a certain amount of rainfall trebled or quadrupled the flow in the sewer, and supposing all the other circumstances were exactly applicable to the greater case of the metropolis, yet owing to the circumstance that in one case the rainfall flows off in a few minutes and in the other it takes a longer time to flow off, the same results will not necessarily follow?—But I should point out that this length of sewer in the same way equalises the flow of the sewage itself in the sewers, and that, therefore, at the minimum period of flow in the day there is more sewage in the sewers than is due to that period, and, therefore, there is not so much room for the rainfall.

(*Mr. Bidder.*) One can imagine circumstances in which, if it rained at each part of the metropolitan area exactly at the proper time, then you would have all the sewers congested at the same moment.

(*Chairman.*) Another thing, I suppose, is that as the sewers get to a distance from their outlet they are smaller in their carrying capacity, are they not.

8131. (*Mr. Bidder.*) Yes, they are. (*To the witness.*) So it does not follow because at Croydon a certain amount of rain will treble or quadruple the amount of water in the sewers, that even under the same circumstances the same thing would happen in the metropolis?—I have already told you that in the south it would only have to be 2·76 times the mean flow, and then there would be an overflow all along the lines; and the same thing applies to any part of the district separately, because this is an aggregation of a number of districts.

8132. Will you kindly follow the question. Is it not the case that owing to the circumstances I have referred to, it does not follow because at Croydon one tenth of an inch will produce a quadrupling of the flow of the sewer, that under the same circumstance the whole of the metropolis would be quadrupled as to the flow in the sewers?—I say it would produce a larger effect, because in the metropolis the whole of the rain goes into the sewers, whereas in Croydon the greater part is excluded; therefore, if you ask me to compare the two things, I say that the fluctuation is likely to be greater in the metropolis than it is at Croydon.

8133. It is quite true to say that there may be elements in the London sewers which would tend to aggravate the point, but it would not follow that because at Croydon one tenth of an inch would produce a quadrupling of the flow of the sewer, the sewage flow over the whole of the metropolis would be quadrupled in the same way?—I can see no difference whatever, because it is necessary to provide each one of those districts with overflows, which has the effect virtually of dividing the metropolis into so many small districts; and, therefore, when any one of those overflows comes into operation it has the effect of separating that district and bringing it under the same conditions as Croydon.

8134. I now go to what I gather has been your principal occupation, and that which you present as the result of your investigation, namely, this report and these voluminous plans and diagrams which you have laid before the Commission. I think those are the principal things which have occupied your attention for the last year?—They are part of the subject which has occupied my attention, but I cannot say that they are the principal things.

8135. I may take it that this being your report it contains what you consider the most important of your views, and of those who are represented on the other side of the table?—That contains our observations.

8136. Upon which you mainly rely?—We do not rely alone upon them.

8137. Is the material supplied in this book and these diagrams material to the inquiry; does it support your case or not?—Certainly it does; it corroborates the other parts of the evidence with regard to the state of the tides.

8138. As I understand, the purport of it is that the sewage apart from the mixing action remains in the river oscillating backwards and forwards for a time, very much longer than the Metropolitan Board of Works say?—We do not say anything about it; we say that it shows the oscillation of the tides, and that wherever those floats have gone sewage may go.

8139. Does not that show that the sewage oscillating up and down remains in the river very much longer than we say it does?—It is confirmatory of the observation that sewage will go wherever the floats go, and you will find with regard to the question of chlorine in the water, that a float has never gone except where there has been sea-water, and, therefore, this is really to test the range of the tide.

8140. I suppose, in fact, we all know that the tide in the Thames is at high water at different times at different parts of the river; that is to say, London Bridge is always a certain number of minutes after Greenwich, and Teddington is a certain time after London Bridge, and so on?—That is so.

8141. How long is the interval between high-water at London Bridge and high-water at Teddington?—Captain Burstal published a table a few months ago showing the high-water all the way down the river; it is one hour and a half from the Nore Light to London Bridge, and it is one hour and twenty minutes from London Bridge to Teddington.

8142. (*Chairman.*) It is nearly three hours from the Nore to Teddington?—Yes.

8143. (*Mr. Bidder.*) So that Teddington high water is one hour and a half after high water at London Bridge?—High water at Teddington is an hour and 20 minutes after high water at London Bridge.

8144. Then we can draw any approximate conclusions as to intermediate places?—Yes.

8145. Let me draw your attention to page 38 of your report; you show there that the duration of a whole tide at Teddington is 12 hours and 13 minutes, the duration at parts lower down the river being 12 hours and 25 minutes. If those observations are correct, the duration of the tide at Teddington is 12 minutes less than at London Bridge and Deptford?—I explained that the exact time of the tide at Teddington was a very difficult matter to arrive at with regard to the time of the tide.

8146. Will you kindly answer the question?—I pointed out that there is a period in which you cannot ascertain really whether it is high water or low water. Those are the exact results of the measurements, without any correction, you may say that it ought to have been 12 hours 24 minutes or 12 hours 25 minutes. I say that there is a period, when you are scaling them off upon the diagram, when it is impossible to ascertain it with certainty at Teddington.

8147. Therefore it is an error?—It is an error to that extent.

8148. (*Chairman.*) To what extent is it an error?—Those are the results of scaling from the diagrams, and whatever they scale, those are the results; but it is a very difficult matter at Teddington to do it, because the top of the tidal wave only is recorded, and you will get a confusion in the tides at this point. There must naturally be the same period of tidal flow all the way up the river. Those are the measurements from the diagram, but these are the measurements all the way up the river (*pointing to the diagram*).

8149. (*Mr. Bidder.*) If you say it is wrong, I will pass from it?—It is not correct to that extent.

8150. (*Sir John Coode.*) I think what the witness means to say is that the development of the time of high water is not so marked at Teddington as it is further down the river?—Yes.

8151. And for that reason it is not possible to ascertain so accurately the moment of high water at Teddington as in the lower parts of the river?—And of low water as well.

(*Chairman.*) What you mean to say is that it is not not so much that it is wrong, as that it must be wrong.

8152. (*Mr. Bidder.*) If high water at Teddington is always an hour and a half after London Bridge, according to these figures, there must be a difference in the tidal wave?—I explained at the time the reason for it.

8153. (*Chairman.*) You did not adopt my suggestion, but, may we take it, that it cannot be right?—We know that the time of the tides cannot be different.

8154. How do you mean?—If I had chosen to take a particular length, and made every day a tidal day instead of scaling them off as we have done, and giving you the exact result by the scale, we could very soon have put in that 12 hours 25 minutes, as it must be all the way down the river. It is not that the observations are in error, but that the computations do not quite tally (*explaining the diagram to the Commissioners*). We have taken in the measurements, the exact scaling of the diagrams, and added them all together.

8155. (*Sir John Coode.*) If you scaled your diagram, why did you not take the records as they were actually observed?—We have taken the records as they were actually observed, but it is difficult to measure both the points of high water and low water at Teddington.

9156. (*Mr. Bidder.*) Now, I pass to what is more important matter in this report. On the same occasion you have given a table with the figures of the results of those floats, which represents in figures what you have represented more graphically in the diagrams?—That is so.

8157. I am not going to take each individually and follow it, but you have given something like six weeks as the duration of your experiments for these floats?—Yes.

8158. And at the bottom of the table you have given the average performance of that float during six weeks?—The average of the column of figures.

8159. Then you have divided that into morning tides and afternoon tides?—Yes, I have.

8160. Just to make that clear a little bit, because the tide is shifting every day; what do you class as a morning tide, and what do you class as an afternoon tide, because, of course, the tide at high water shifts day by day?—As a morning tide, I class any tide of which the largest part is between 12 at midnight and 12 at noon, and as an afternoon tide I class any tide of which the largest part is between 12 o'clock at noon and 12 at midnight.

8161. (*Chairman.*) If it were high tide now (2.30 p.m.) what would you call it?—A morning tide; but if you see where it crosses the line at 12 at night if the biggest part of it were before midnight, that would be put down as an afternoon tide, and if the biggest part of it occurred in the morning, that would be put down as a morning tide.

8162. (*Mr. Bidder.*) Take high water 1 o'clock in the afternoon, is that a morning or an afternoon tide?—1 o'clock would be a morning tide, because the biggest part of it is in the morning.

8163. High water at 2 o'clock would be a morning tide?—Yes.

8164. Up to 3 o'clock it would be a morning tide?—Yes.

8165. And high water at 4 o'clock would be an afternoon tide?—Yes.

8166. And so up to 6 and 7 and 8 and 9 in the evening up to midnight would all be afternoon tides?—Yes.

8167. Then in point of fact, it comes to this: That whenever the greatest amount of flow is in the afternoon period, it goes into that period of the day, and whenever the greatest amount of flow is in the other period of the day, it goes into the morning period?—Yes.

8168. Where the tide is between 3 in the morning and 3 in the afternoon, it is a morning tide, and when the tide is between 3 in the afternoon and 3 in the morning, it is an afternoon tide?—That is so.

8169. Now to take Float No. 1. I see that of Float No. 1 the average performance was this: that upon the morning tides it went down 12½ miles, and came up 12·26 per diem, so that it went a quarter of a mile down the river every morning tide, upon the average; is not that right?—On an average tide.

8170. Upon the morning tide?—Yes.

8171. For the average of the whole six weeks morning tides, it went down to a quarter of a mile?—Yes.

8172. On afternoon tides it went down 13·09 miles and went up 13·24 miles, so that upon the afternoon tides it went up instead of down a fifth of a mile upon each tide?—Yes.

8173. How can you explain rationally the fact that the difference between the morning and afternoon tide should make a difference between going up and down the river?—I say that the whole range of the tides in this particular period is greater; there is a diurnal difference in the period of the tide, which is greater in the afternoon.

8174. Supposing that there is a diurnal difference, which makes the afternoon tide stronger than the other, do you suggest ——?—The greater impulse would occur upon the flood tide only, and therefore it would affect that particular tide.

8175. Do you believe it is the fact that the morning tides of the river Thames are a quarter of a mile stronger upon the ebb, while the afternoon tides are

*Mr. B. Latham, M. Inst. C.E.*

3 Jan. 1883.

quarter of a mile stronger upon the flood?—Yes, at this particular period of the year; in the summer-time they change about the other way.

8176. Have you any authority for this suggestion as to the preponderance of strength in the afternoon flood and morning ebb tides?—I have already told you that this diurnal fluctuation in the flow of the tides affects the afternoon tides in the winter, and in summer it affects the morning tides.

8177. (*Chairman.*) Is this recognised?—Yes, it is a well-known fact; it is due to the position of the earth with regard to the sun.

8178. (*Mr. Bidder.*) I am quite aware that there is what is known to astronomers as a diurnal variation in the tide, but that is a variation in the height of the tide?—But whatever varies the height must vary the velocity of flow to increase that height.

8179. Both on flood and ebb?—Yes; but more on the flood; as I have already pointed out to you the velocity of the flood tide is very much more than that of the ebb tide.

8180. Does not the question whether upon the whole tide the balance of progress is down or not depend upon this, whether the amount of land water which is coming over Teddington Weir, and the other tributaries in the interval, is not an excess quantity over and above what is required in the case of spring tides to make up the increase of the tide?—I say that the amount of land water has nothing whatever to do with this question of tidal oscillation.

8181. (*Chairman.*) Supposing we got a place where there was no land water, no back water of any kind—take, if you like, the coast at Brighton; do you mean that the afternoon tides, as you call them, rise higher than the morning tides?—Yes, at this period of the year; and in the summer time it is just the reverse; then the morning tides are the most affected.

8182. The afternoon tides rise higher you say than the morning tides?—Yes, at this period of the year.

8183. Do not they also fall lower?—There is a greater range of tides altogether, and whenever they rise higher they fall lower.

8184. Then I do not see why your log should have made a voyage up the river?—For this reason, that there is a greater difference of proportionate velocity between the flood and ebb tide.

8185. (*Mr. Bidder.*) Suppose at Brighton you had an estuary running inland, into which no tributary water ran of any kind, but which was simply filled and emptied by the efflux and influx of the tide, if the tide rose higher more water would come in?—Yes.

8186. And more water would go out upon the ebb?—Certainly.

8187. And at the end of the 12 hours there would be the same water left in the inlet as at the beginning?—And there might be less.

8188. But upon the average extending over two or three lunations it would be the same?—It might be.

8189. Otherwise let me ask you if it is true upon that one observation that the two tides if we combine them together have almost exactly neutralised each other?—Yes; I say that there is nothing in this table to which you have drawn attention which is contrary to what is known with regard to the movement of tidal water.

(*Chairman.*) Supposing there has been some inaccuracy in the observation of these logs; supposing sometimes when the tide was going down they got stranded, and when they were going up they never got stranded, does not, after all, the witness's table show that the water (I will not say sewage, because it might hurt your feelings) is oscillating there somewhat in the way he describes.

(*Mr. Bidder.*) Nobody disputes that sewage oscillates; that is admitted by everybody.

(*Chairman.*) It may be wrong to say that the log or float ever could have got higher than the point it started from at the end of a month's journey even, but supposing it were a mile short of that, do you see what I mean.

(*Mr. Bidder.*) I see what your lordship means, but assuming, as I am bound to assume, that this report has some relevance to the case, the matter is not a question of principle affirmatively whether there is oscillation or not, because nobody doubts that, nobody pretends that the sewage goes straight away to the sea upon the same tide as that upon which it is poured in, but it is a matter of degree.

(*Chairman.*) As I understand the effect of these experiments is that the sewage oscillates about in the river without ever going down at all until floods come.

(*Mr Bidder.*) That it remains in the river four or five times as long as we believe it does.

(*Chairman.*) It is not a minute question, but a substantial question.

(*Mr. Bidder.*) Yes, turning upon questions of figures which possibly at the first glance might appear to be minute.

(*Chairman.*) What would carry the log out to sea is the fresh water which is introduced into the river.

(*Mr. Bidder.*) The preponderance of it.

(*Chairman.*) I asked the witness on the last occasion, and I think he could not answer me, whether the downward progression of his floats was proportionate to or corresponded with the total bulk of the river water that was introduced.

(*Mr. Bidder.*) I am going to deal with that; but meanwhile, as to the question of whether it is a minute difference between us. Minute is a relative term, and when I tell you what our views are, you will be better able to judge whether it is minute or not. We do not suggest that the sewage goes down in its progress seaward more than half a mile a day after the return tide, that is, apart from the mixing action, that the mere effect of the land water upon the average would not take it more than half a mile a day out.

(*Chairman.*) That is to say a float would go down at the rate of half a mile a day.

(*Mr. Bidder.*) If you could have a float which would truly represent the average of the river, that would be all you would get.

(*Chairman.*) Would you accept that?

(*Witness.*) The question of oscillation is totally distinct from that of progression. We have put the matter much more favourably, because the moment we put the mixing action before you we show that the sewage goes out much more quickly than it was formerly supposed to go, when it was only supposed to move by displacement. Mixing is much in excess of ordinary displacement.

8190. (*Chairman.*) Would you accept the concession that the float would go down at the rate of half a mile a day?—No, I do not accept that because I go by what the floats have done. I have already stated in this report that in the original experiment made by the Metropolitan Board of Works, taking the result of their floats, and the average of their period of experiment, their float only went down one third of a mile.

(*Sir P. Benson-Maxwell.*) You made it one twenty-fifth of a mile.

(*Mr. Bidder.*) I want to satisfy the Commission that all this is absolutely worthless. I say plainly what I am driving at now, that these observations are not worth the paper they are written upon from beginning to end.

(*Witness.*) It is singular that you should have thought them of so much importance as to have them all checked by having floats out and men checking them.

(*Mr. Bidder.*) I say boldly that I challenge the whole lot of observations as absolutely worthless.

(*Chairman.*) Do you mean as being erroneous or as proving nothing?

(*Mr. Bidder.*) Both my lord. I am not suggesting that anybody has purposely vitiated them; but that whether by carelessness or by ignorance the whole set of observations is utterly and absolutely worthless.

(*Witness.*) That is only an assertion. Perhaps you will point out where they are erroneous.

(*Mr. Bidder.*) Now let me ask you to take into your hand a diagram we have prepared which purports to represent what happened simultaneously to No. 2 and No. 3 floats, and I will ask you to check it by your tables and tell me whether it is accurate. This is diagram A (*handing the same to the witness**) showing contradictory results in the float experiment. The full line coloured red shows the progress made up the river by Float No. 3 in five tides, commencing at high water September 18th, 1882, the dotted line coloured yellow shows the progress down the river made by the same float during the same times, and commencing at Greenwich. I invite you to check that by your own observations and diagrams, and tell us whether that correctly represents the results of observations during the same time. That shows where it was at the beginning of the first tide, and where it was at the end of the fifth. One had gone up the river two and three quarter miles whilst the other had been going down the river four and three quarter miles. That is the result of five successive tides.

(*Chairman.*) At the same two hours or three hours, or what not, the floats are going different ways in the river.

(*Mr. Bidder.*) Not two hours or three hours, but for five successive tides. that is 60 odd hours, starting at the same moment.

(*Witness.*) That can easily be accounted for. It is quite a well understood thing for the tide to be running two ways in the river at the same time, it begins to run out at the mouth before it has ceased running up at the top. If your engineers have corrected it I must take it from you, I have now no opportunity of doing it.

(*Mr. Bidder.*) Float No. 2, upon the 18th of September was, according to the diagram, opposite to Greenwich Station at high-water, at a mileage of $6\frac{3}{4}$ miles. Now, if you take the fifth tide afterwards, you will see that it was at Woolwich station at two miles, showing that it had gone down $4\frac{3}{4}$ miles; therefore that establishes the accuracy of the diagram I have put in as far as Float No. 2 is concerned. Now, if you take Float No. 3 upon the same day, you will see that upon the 18th of September it was at Lambeth Bridge at 14 miles, and five tides further on it was opposite Chelsea Bridge at $16\frac{1}{2}$ miles; so that it had gone up practically $2\frac{1}{2}$ miles, while the other had been going down $4\frac{3}{4}$ miles. That is the fact. Now will you give us any explanation you like.

(*Chairman.*) It comes to this; that the float at Lambeth Bridge in five tides makes $2\frac{1}{2}$ miles up the river, while upon the same five tides the float at Greenwich makes $4\frac{1}{2}$ miles down the river.

(*The witness examined his diagram.*)

(*Mr. Bidder.*) If you have nothing to say as to that for the moment I will ask you to go to another diagram marked B. I will ask you to go to Nos. 4 and 5 Floats, which were also taken simultaneously.

(*Chairman to Mr. Bidder.*) Do you say that after a time those two floats behave as they ought to do, so to speak; do they get right again in relation to each other?

(*Mr. Bidder.*) I can believe them to be capable of doing anything. There is no law that they observe.

(*Witness.*) If you observe upon the 23rd of September the general tendency is downwards in them all; they follow the range of the tide.

8191. (*Mr. Bidder.*) That is upwards? — Yes. There may have been no end of accidental circumstances which may have interfered with a particular float for a short time, especially in that higher part of the river where the river is shallow.

8192. We will go to lower down the river. You have now the diagram of Nos. 4 and 5, and that in the same way shows that in three successive tides No. 5 went up the river, No. 5 being at Greenwich, the same place as the float distinguished itself in the last case by going down so much. No. 5 went up the river just under a mile, whilst No. 4, a little lower down, went down the river nearly four miles?—That corroborates the accuracy of the other two floats, which were put in at exactly corresponding periods of the tide. No. 2 was put in at half tide, and No. 5 was put in at half tide.

8193. What rational suggestion can you make for the river at Greenwich flowing up upon the average of three tides, whilst the river at Woolwich flowed down? — Because there may be certain differences with regard to the shape of the river, and the direction of the wind in particular places which may affect the floats.

8194. Where did the water come from between Greenwich and Woolwich which supplied the preponderating influence? — But the floats may be effected by wind as well as by water; so that there is nothing in that.

8195. That is what I was to come to; that the float is effected by wind as well as by water?—But at the same time that does not detract from the importance of the fact that wherever the float is found there sewage will be found.

(*Chairman to Mr. Bidder.*) When the float is represented as going up the river, that of course is with a rising tide.

(*Mr. Bidder.*) It must have gone up upon the flowing tide.

(*Chairman.*) The witness never represents the float as going down the river at that time, does he?

(*Mr. Bidder.*) No; but what we are talking of is not the actual motion, but the balance of motion.

(*Sir John Coode.*) Not necessarily.

(*Mr. Bidder.*) If it is towed by the boat, or if it has grounded then there may be a tendency to go in another direction.

(*Chairman.*) I gather that one float in the course of a 12 hours tide up and down, has made upward way to a certain extent, while another float in the course of the same tide up and down has made downward way.

(*Witness.*) That is so; but the floats are in a different part of the river. The diagrams which have been put in show that they are in different parts of the river.

(*Mr. Bidder.*) I would venture to say that that does not account for it. In point of fact you must not accept that as the fact, because what the diagrams shows is the position of the float at the beginning and at the end of the experiment.

(*Witness.*) You will observe as to both No. 3 and No. 5, which are floats which are put in at half ebb, that one corroborates the other; they both went up.

(*Mr. Bidder.*) No, they did not.

(*Witness.*) According to your diagram which you have just put in, they do.

8196. (*Mr. Bidder.*) No. 5, which is the former in the upward direction in the last diagram, is in the very part of the river where preponderance was downward in the previous one. Now I will take another date, the 29th of September. This diagram is labelled C (*handing the same to the witness*). This shows, and I invite you to say if it is inaccurate, that No. 2 in two tides went up three miles, whilst at the very same time No. 4 went down four and a quarter miles? —That exactly corroborates the same thing with regard to the other floats, and they were all watched by different observers, therefore it is utterly impossible for there to be such a collusion as you would suggest, and that these are in error, for these floats are corroborated one by the other. I say that is the real true progress made by the floats in one part of the river and in another.

8197. I did not suggest any collusion?—I think you suggested on the last occasion that the floats were anchored at night.

(*Mr Bidder.*) I did suggest that those floats were very difficult things to keep sight of at night, and that it was quite possible that the float might have

* The diagrams put to the witness by the cross-examining counsel will be put in at a future time.

been attached to the stern of the boat. Our floats had lamps upon them, but theirs had not. Now take the D diagram (*handing the same to the witness*). No. 2 float and No. 7 float started very near together, about a mile and a half off each other, and No. 2 float, the yellow one, in 15 tides had moved up the river a mile and a quarter, whereas float No. 7 had gone up the river 10½ miles in the very same time; that is to say, one had started a mile and a half above the other, and left off about 10 or 11 miles ahead of it. What do you say to that. That is commencing at high water October 6th, on which date Float No, 7 was at six miles, being just below Greenwich station; now if you look on to October the 14th it was 16½ miles, opposite old Chelsea bridge so that it had gone up 10½ miles.

(*Chairman.*) But where had the other gone upon the 16th.

(*Mr. Bidder.*) On October the 16th it was at Angerstein's wharf, four miles, and upon the 14th it was opposite the West India Dock, mileage 5¼. I think that corroborates the figures given in the diagram. You will find one went a mile and a quarter up, and the other went ten and a half miles, and yet they started exactly two miles apart; and you will remember that they had been oscillating up and down the same parts of the river. Having drawn your attention to that will you now refer to diagram E (*handing a diagram to the witness*). In the last case, as Sir John Coode will see, the one float starting two miles higher up the river than the other, gained nine miles upon it. Now I take a case where exactly the opposite thing happened. In this diagram E, which is before the Commission, in two tides from the 16th of October 1882, Float No. 1, which started at Crossness, went up 8½ miles, while No. 2, which started at Greenwich, and therefore ought to have done a great deal better, went up only a mile and a half, in fact within 24 hours, the lower Float gained seven miles upon the upper one.

(*Witness.*) That would be affected by the amount of land water coming down then.

8198. How did the land-water stop the first, and escape the other down below it?—For the simple reason that the land-water has less effect in the lower part of the river; the higher it is up, the more it will affect the float.

8199. They had been practically in the same part of the river, because you must recollect they are oscillating up and down.

(*Sir John Coode to Mr. Bidder.*) There is one thing I have to call attention to, and that is that upon the 16th there are 116,000 cubic feet of water coming down, and upon the 17th there are 288,000 cubic feet, therefore that quantity of water would be tending to carry the float further down.

(*Mr. Bidder.*) But why should it stop one and not the other, being, as they were, in the same part of the river.

(*Sir John Coode.*) But the impulse is very much greater in the narrower part of the river.

(*Mr Bidder.*) But where they leave off the lower float is not a mile and a half distant from the other.

(*Sir John Coode.*) Because in the mean time probably the flood tide has come up and overridden the water coming down from Teddington Weir.

(*Mr. Bidder.*) But these floats have been twice up and down in the same part of the river, and let me draw attention also to this; that the flood water is not strong, for both those floats are making their way up the river; they are not being borne down by the flood water.

(*Chairman.*) What Sir John Coode says is that the higher you go up the river the greater the power of the up-land water to stop the rising tide.

(*Mr. Bidder.*) If that is the cause which has produced this extraordinary difference of seven miles in neighbouring parts of the river; there must have been a very strong land-water, and how do you account for both the floats going up the river in the face of that land water?

(*Sir John Coode.*) But you must not forget the relative sectional areas of the river at the different points.

(*Chairman.*) I should think no amount of land-water is operative at Sheerness for example.

(*Witness.*) That is so.

(*Chairman.*) Then the lower you go the greater the sectional area, as Sir John Coode says.

(*Witness.*) You will see also that upon the 17th of October there is a tendency for a little more water to be going up the river.

(*Mr. Bidder.*) But it will be seen that the explanation of the one diagram here destroys the other. In diagram E you find that the upper float has made little progress up the river, whereas the lower float has made very great progress. Explanation suggested that that is the effect of the land-water, which is more marked in the upper reaches of the river than in the lower, where the sectional area is larger; but in diagram B the upper float makes a progress up the river, while the lower float is swept out to sea. If the restricted section of the river had anything to do with it, that would be fatal to the first explanation.

(*Sir John Coode.*) Upon the 29th and 30th of September there is only half the water coming over Teddington Weir.

(*Mr. Bidder.*) It ought to have the same relative effect.

(*Chairman.*) When you say the sewage goes down at the rate of half a mile a day, that cannot be all the length of the river; you must mean at the outfall

(*Mr. Bidder.*) When I said half a mile a day, I believe that applies to the district in the neighbourhood of Crossness. Of course, as you go further down there would be a diminution corresponding. We are speaking there of the downward motion as produced by the pushing down influence of the land-water.

8200. (*To the witness.*) Am I right in treating that half a mile a day as due to the theoretical displacement of the sewage by the pushing down of the land water?—It all depends upon the amount of the land water coming down. I have not worked it out.

8201. We will work it out now. You gave us the other day the amount of land-water, you told us that the average amount of land-water over Teddington Weir and the tributaries above the outfall was 120,000 cubic feet a minute. I think I am right in that?—I think I gave the mean flow as being 30 cubic feet from a square mile, which I believe is very nearly the quantity that came down upon the 22nd of September.

8202. Taking that 30 cubic feet that corresponds with my 120,000 cubic feet. Now your own table shows that at Crossness the sectional area is at high water about 75,000 square feet, and at low water 30,000 odd?—At high water at Crossness 75,000 and at low water 30,000.

8203. That 120,000 feet a minute passing that sectional area would give you a downward motion of a little over 18 inches a minute at high water at 1·6 or 1·7 of a foot, dividing the sectional area into 120,000?—I am taking the mean between high and low water. Taking it at 120,000, it is 2·28 feet a minute.

8204. That would be equal to three quarters of a mile a day at that spot?—It gives 3,283 feet.

8205. Consequently I am right in this: that taking the mean effect the whole year round if there were no mixing action, and if the water at Teddington weir were pushed into the river like so many successive charges from the tube of a gun, it ought to pass Crossness at the rate of three quarters of a mile a day?—Yes; that was upon the old theory of displacement, but we have pointed out that by reason of the mixing action it goes very much quicker, because instead of that same volume of up-land water displacing the whole of the water in the channel, it has only to displace that part of the body of water in the channel which is occupied by the fresh water and the sewage itself.

8206. That you say would be varied in other parts of the river by the increase or decrease of the section?—The displacement theory would assume that there is the same proportionate amount of fresh water in the river all the way down, and that the motion would gradually become slower and slower as the section increased.

8207. Your mixing theory would be another influence superimposed upon that, helping to distribute the sewage and to accelerate its progress lower down?—Yes, that is so; but the mixing action is so great that it overrides altogether the influence of displacement as put by you.

8208. But its action is in the same direction, to carry it down seaward?—Yes.

8209. Now to come back once more to the general result of your floats. Inasmuch as the land water, would as you say, drive down past Crossness at the average rate of three quarters of a mile per day, the result of your float experiment is, on the whole, to show not a tenth part of that; is it?—I say the floats have nothing whatever to do with this question of displacement. One simply shows the oscillation of the tides and the other shows what is the natural displacement in the river by the quantity of fresh water coming down.

8210. Then will you now admit that what happened with the floats is no guide as to what happened with the sewage?—No; I say these floats show that whatever happens with the floats may happen with the sewage; wherever they go sewage may go.

8211. (*Chairman.*) I think you say that if there were displacement only it would be at the rate of three-quarters of a mile a day?—Three-fifths of a mile a day.

8212. If that were so, if the float had been kept in the displaced sewage, it would have gone down at the rate of three-quarters of a mile a day?—Yes, if the float could have obeyed the natural flow of the stream, which it cannot, as the velocity in every part of the stream varies. One float cannot give the mean velocity of the stream; therefore you get these apparently discordant results.

8213. If the float had been a part of the sewage, as we may assume, it would have gone down the stream at the rate of three-quarters of a mile a day?—Yes, the total volume would; but I am pointing out that a particle of sewage would obey the same action as the float.

8214. The action of the floats, therefore, conveys an erroneous impression?—They give the range of the tides, and not the progression out of the river.

8215. (*Mr. Bidder.*) Then, as showing what would happen to the sewage, you mean that if you had an atom of sewage twelve feet long and one foot out of the water (supposing such a thing to be possible), it might possibly follow the same rules as the float did; but as we do not generally get atoms of sewage of that dimension it does not give a very good idea of the motion of the sewage?—It gives the range, but it does not give the rate of progression.

8216. Does it give even that?—It does not give the actual mean of the oscillations.

8217. Does it give the actual fact in any particular tide, because how can the floats have gone wrong at all if these observations are right?—If you started two floats together in any tidal river, you would, in all probability, find that they acted very differently from each other.

(*Chairman.*) Supposing the float came out of the reservoir with the sewage, one would suppose that it would go as fast as the sewage; and leaving the mixing action alone one would suppose that it ought to go down the river at the rate of three-quarters of a mile a day. I do not say that the sewage may not find its way up the river, because a quantity of sewage may get a certain distance up, and then it may stop in an eddy, and it may be again carried up by the next up tide and taken still further; but it seems to me that what Mr. Bidder is contending for is demonstrated.

(*Witness.*) I say the floats only show the horizontal oscillation, and have nothing whatever to do with the ordinary displacement.

8218. (*Sir P. Benson Maxwell.*) Mr. Bidder made a statement to the effect that the sewage did go at a certain slow rate. Now either your tables go to contradict that statement, or they do not; if you admit that they do not, then surely the cross-examination may be very materially shortened; do they contradict it?—What we say is that the floats only show the oscillation, and have nothing whatever to do with the progress. We have already shown the progress. We admit Mr. Bidder's argument with regard to the displacement, and we have given evidence as to the mixing action, showing that the sewage does get out of the river under varied circumstances.

8219. Then these floats do not contradict Mr. Bidder?—They do not.

8220. (*Mr. Bidder.*) But nevertheless these floats are large bodies 12 feet high, and not obeying the flow of the water; whereas the sewage is in minute particles in suspension and obeying every motion of the water?—I admit that; but still there is evidence to show that wherever these floats have gone sea water has gone, and wherever sea water has gone sewage has gone; because the sea water could not have been carried up the river past the outfalls without carrying sewage with it.

8221. That is mixing together two things: the sea water and sewage got up by the mixing action, but you could not say that the float got up by the mixing action?—No, I do not say that.

8222. Now you do not at all dispute that as regards the great bulk of the sewage poured in at the outfalls, apart from the mixing action, the average mean effect is to drive it down below Crossness at the rate of three-quarters of a mile a day, the rate diminishing as the section grows bigger?—And that is affected also by the range, because that sewage is brought up by the tide a certain distance before it goes down again.

8223. Without discussing whether particular particles of the sewage may or may not find their way up to Westminster, for example, do you dispute that as regards the general mass of the sewage poured in at Crossness and Barking the mean progress seaward would be three-quarters of a mile a day at Crossness, and slower as the sectional area grows larger, apart from any mixing action?—That is the law which governs displacement.

8224. Then let me draw your attention to this: you talked about your chlorine diagrams. There seem to be some difficulties, as far as we understand them, in following out some inconsistencies in them; you referred us to page 6 of the blue paper diagrams, and you there give us tests showing the quantity of chlorine, and the quantity of up-river water mixed with each volume of tidal water on several days. I quote this because you refer to this as corroborating some other views of yours. I see you show there the quantity of upper river water mixed with each volume of tidal water at St. Paul's Pier as being 8·2; does that mean that there was eight times as much river water as sea water?—That is the ratio between them.

8225. I will take first low water, when there was 803 times as much river water as sea water?—Yes.

8226. Now, will you refer to another table that you put in upon the very same day; at the very same low water you show 983 times as much river water as sea water?—The explanation is very easy.

8227. I want to get the fact?—The fact is that in the blue table the tidal water, which it is compared with, is Southend water, whereas the ratio in the white table is the ratio compared with sea water. I made those tables to show how little difference there was in the mixing.

8228. Is it not that the one contains the sewage and the other does not?—No, not wholly. The blue table is headed "Table produced from chlorine tests "showing the quantity of upper river (Teddington)

*Mr. B. Latham, M. Inst. C.E.*
31 Jan. 1883.

"water mixed with each volume of tidal (Southend) "water at various places in the Thames."

8229. The difference is as between 983 in the one table and 803 in the other; that is a difference in the ratio of 4 to 5. Therefore, if that is due to the standard being Southend water, the difference between Southend water and sea water is as four to five in chlorine?—But you must bear in mind also that this water in (*explaining the Table, see* Q. 7997) is upper river (Teddington) water, and has nothing whatever to do with sewage. Both explanations are necessary. It is quite true I have taken the two ends of the river to show what is the effect of the mixing; in one case Teddington water, and in the other case Southend water, without its having anything to do with the sewage.

8230. Does the difference between the two figures represent the sewage?—No.

8231. Is it because you have taken Teddington water in one case, and Southend water in the other?—I have taken both. I have taken river water and Southend water, both in the blue paper; in the white paper you have river water, sea water, and sewage.

8232. At low water the difference in the two tables, whether it is accounted for by the one containing sewage or not I do not know, is as between 803 and 983; that is a difference in the ratio of 4 to 5. Now, look at high water; one is 8·2, and the other 8·4; that is only the difference between 39 and 40?—That is what you would expect.

(*The witness explained the table to the Commissioners.*)

(*Sir John Coode.*) I have a suggestion to make which I think would bring out the facts which Mr. Latham has arrived at in a form much more useful to all of us; that is, if he could have plotted out a longitudinal section of the river surface at high-water and low-water. We should then see the gradients of the water surfaces under different conditions, and I think that would throw light upon this anomaly.

(*Mr. Bidder.*) If you are not satisfied already that these float experiments are worthless I shall be able to satisfy you by direct positive evidence that they are.

(*Witness.*) These sections have been made and will be brought before the Commissioners by Mr. Mansergh.

Adjourned to Tuesday next at half-past 12 o'clock.

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# NINETEENTH DAY.

## Tuesday, 6th February 1883.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
FRANCOIS DE CHAUMONT Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
JAMES ABERNETHY, Esq., F.R.S., Mem. Inst. C.E.
WILLIAM POLE, Esq., F.R.S., *Secretary.*

Mr. BALDWIN LATHAM, Mem. Inst. C.E., further cross-examined.

6 Feb. 1883.

8233. (*Mr. Bidder.*) I will just ask you at once, as you have had a week to look into the matter, if you have any further observations to make with regard to these anomalies to which I drew your attention in your float experiments?—(*The witness handed in some diagrams, see Appendix A.D.*) These diagrams will explain the whole of the float observations during the period in which you say there are anomalies.

8234. Will you draw attention to anything in what you have handed in which throws any light, or which you think does so, upon these anomalies?—First of all, I will deal with Diagram A. of those which were put in by Mr. Bidder. I have here tracings which have the range of all the floats put on them, and which will, therefore, be more easily intelligible.

8235. Our diagram A. showed that No. 3 float went up a certain number of tides whilst No. 2 went down?—Yes; in Diagram A. the observations extend over five tides from the 18th to the 20th of September 1882, commencing with No. 3 Float at high water at Lambeth Bridge upon the 18th of September, and the comparison is between No. 2 and No. 3 Floats. Upon the diagrams which I have prepared, I have adhered to the same colour as you adopted in your diagrams. You will find that No. 2 Float, which is coloured yellow, starts at Greenwich and goes down the river, while No. 3 Float, which is coloured red, starts at Lambeth and goes up the river. At the commencement of the observations the floats are seven miles apart. At this time there were only three floats in the river, but it will be found, from comparing the diagrams, that No. 2 Float conforms with No. 1 Float, and No. 3 Float in the upper part of the river also shows a general conformity upon the 24th of September. No. 1 is coloured blue, No. 3 is coloured red, and No. 2 yellow, and you will find that the yellow and the blue conform generally (*pointing to the diagram*). Then upon the 24th of the month you will find that the other float implicated conforms.

8236. (*Chairman.*) Are these floats numbered as you had numbered them in your original paper?—Yes, they are numbered and coloured according to the plans put in by the Metropolitan Board of Works.

8237. (*Sir John Coode.*) You are speaking of the 18th and 20th of September, are you not?—Yes.

8238. But on this date this No. 1 Float does not appear?—No, but I have put it in as showing that it establishes the correctness of the movements of No. 2 Float.

8239. (*Mr. Bidder.*) But before you go any further will you allow me to ask you now, what do you suggest to the Commission as the reason why?—I will deal with them all, and then I will give my reason. I have one reason to give, which I suggest will apply to all these floats and explain their movements.

8240. But as I am cross-examining, I have the right to ask you, how do you suggest the fact is accounted for that the one float in a certain number of tides works up the river while the other float works down?—I will give you that when I have dealt with them all.

(The *Chairman* ruled that the witness was entitled to give a complete answer to the original question.)

(*Witness.*) No. 2 therefore conforms with No. 1 Float, but No. 3 differs; that No. 3 Float, however, is in the upper and shallower part of the river, and you will also find that upon the 21st of September No. 2 Float which is one of the floats implicated, went up.

8241. (*Mr. Bidder.*) But upon that other statement, that No. 2 Float conforms with No. 1, let me draw your attention to the diagram, from which it seems that it does not do anything of the kind; occasionally it does, but No. 2 is going up the river whilst No. 1 is going down. Your own diagram, for instance, shows that, if you take the 28th, the 29th, and the 30th of September, the No. 2 Float goes up the river and No. 1 goes down; how can you say that they conform?—I say that upon these particular dates which I have given to you they conform, and I have already called attention to the fact that No. 2 Float conforms to the action of No. 1 Float. At the beginning No. 1 Float goes down as well as No. 2.

8242. (*Chairman.*) No. 3 Float goes up?—No. 3 Float goes up, that being in a different part of the river; in fact, they are seven miles apart at the commencement.

8243. (*Mr. Bidder.*) But I venture to draw your attention to this,—that is, suggesting of course that there is something going on at one part of the river, common to No. 1 and No. 2, which is different from what is going on in the other parts of the river, where Floats Nos. 3 and 6 are?—That is the fact.

8244. Upon that I draw your attention to the fact that No. 1 and No. 2 conform at the time when they get closest together, that is to say, between the 28th and 29th of September. Now your diagrams show that from the 28th of September to the 30th of September No. 2 goes four miles up the river, whilst during the same period No. 1 goes down about two miles; if that is conformity, I do not know what is not; do you see that?—I do not see any irregularity at all in it, but I shall be glad if you will allow me to finish this one float first, because I am coming to the other dates, and I shall have remarks to make upon that point.

(*Chairman.*) If we are to understand the witness, we had better hear what he has to say upon the subject.

(*Witness.*) A very important point in the case is the direction of the wind. Upon the 18th of September the wind was N.N.W. and N. in the morning, and N.N.E. in the afternoon; upon the 19th the wind was N. and N.N.W., and in the afternoon it was N.W., N.N.W., and N.N.E.; upon the 20th, in the morning the wind was N.N.E; N.E., and in the afternoon it was E.N.E., E.S.E., and N.E.; the cardinal points are put upon my tracing, so you will see them. Now, by comparing the lower as well as the upper range of the floats, which are shown upon my diagram by dotted lines of the same colour, it will be seen that No. 3 Float is in conformity at both ends,—that is, the red float, which is in the higher part of the river. It will also be seen that No. 2 Float upon the 18th went up, so that there was some influence at work upon the 18th in the river which affected the floats. With regard to Diagram B., it only refers to three tides, the former one referring to five tides. Now, commencing with No. 5 Float from a point a little below Greenwich on the 22nd of September 1882, the comparison is between No. 5 Float and No. 4 Float. No. 4 Float, commencing off Woolwich, goes down, while No. 5 Float, commencing a little below Greenwich, goes up. The floats were over four miles apart at the commencement. During part of this time six floats were in the river. No. 4 Float generally conforms with No. 1, No. 2, and the lower range of No. 3 Floats; (that is important, because you will observe that the floats conform at the lower part when they do not conform at the upper part, that is to say, while the two floats are in the same part of the river, they conform to each other, but if they are in different parts of the river, there may be a disagreement); while No. 5 generally conforms with No. 3 and No. 6, which are in the higher parts of the river.



8245. (*Mr. Bidder.*) Upon what day is that?—That is from the 22nd to the 24th September; I am referring to your B. diagram. The direction of the wind upon the 22nd in the morning was N. and N.N.E., and in the afternoon it was also N. and N.N.E.; upon the 23rd in the morning it was a calm, and in the afternoon it was S.S.E. and S.S.W.; upon the 24th in the morning the wind was S. and S.W., and in the afternoon S.S.W. and S.E. No. 4 Float conforms with No. 3 and No. 1. The No. 5 Float was under an influence which was taking it to the upper part of the river, but it will be seen by comparing the lower range as well as the upper that there is nothing to throw doubt on the operations of this float.

8246. But I wish to call your attention to the fact that No. 3 Float was further up the river than No. 5 Float; when you say that No. 4 Float conforms with it, being in the same part of the river, No. 5 is between No. 4 and No. 3?—I am only speaking of their movement, which shows that there is a conformity between them.

8247. That is to say that some of them happen to be moving in the same direction; but, however, I will not ask you any questions just now.

8248. (*Chairman.*) Have you finished your statement?—As far as the B. diagram is concerned. Now, dealing with the C. diagram, these observations extend only to two tides on the 29th and 30th of September, commencing with No. 2 Float at high water, and the comparison is between No. 2 and No. 4 Floats. No. 2 Float off Greenwich goes up while No. 4 Float off Blackwall goes down. The floats are two miles apart at the commencement. No. 2 Float happened to get into the range of the influence of the higher part of the river, and conforms with No. 3, No. 5, and No. 6; No. 3 being red, No. 5 the neutral tint, and No. 6 burnt sienna. No. 4 Float conforms generally with No. 1 Float in the same part of the river, No. 1 Float being the blue and No. 4 the green. The wind upon the 29th in the morning was E.S.E., W.S.W., and N.W., and in the afternoon it was N.W. and S.W. Upon the 30th in the morning the wind was S.W., and in the afternoon S. and S.S.W. By comparing the lower as well as the upper range of the tides, both those tides will be seen to agree. There is a general conformity if you compare the lower ends, especially when they come into the lower part of the river. That concludes my observation as to Diagram C. Now, dealing with Diagram D., which gives observations upon 15 tides, commencing at high water from the 6th of October to the 14th of October with No. 7 Float, a little above the West India Dock, the following is the comparison between No. 2 Float and No. 7 Float. No. 2 Float at Angerstein's Wharf goes up, and No. 7 Float at the West India Dock also goes up; the floats are two miles apart at the commencement; No. 2 Float conforms with the lower range of No. 3, No. 5, and No. 6.

8249. (*Mr. Bidder.*) You must not say, conforms to No. 3 and No. 5, because No. 3 and No. 5 are one float. After a certain date they were not two floats, but the figures for No. 3 were taken as representing No. 5?—Exactly.

8250. If you choose to give it two names, that is your concern, but that must not be taken for the purpose of evidence, you know?—After the 5th of October there is a note upon the printed table which has been already put in, that "The figures of No. 5 "Float observations from the afternoon of the 5th of "October to the end of the experiment are the same "as of No. 3 Float."

8251. That shows a curious thing, that the two floats should come together, having been in different parts of the river?—Then No. 7 conforms with No. 3 (or No. 5) and No. 6 in the upper part of the river. Now the direction of the wind was as follows. Upon the 6th of October in the morning it was E.N.E., and

*Mr. B. Latham, M. Inst. C.E.*

6 Feb. 1883.

in the afternoon E.N.E. Upon the morning of the 7th it was E.N.E. and S.E., and in the afternoon S.E. and E. Upon the morning of the 8th it was N.E. and S.E., and in the afternoon it was S.S.E. Upon the morning of the 9th it was a calm, S. and S.S.W., and in the afternoon S.S.W. and S. Upon the 10th in the morning it was N.E. and E., and in the afternoon it was E., S., and S.S.W. Upon the morning of the 11th it was S.S.E., S.S.W., and S., and in the afternoon it was S.S.W. Upon the morning of the 12th it was W.S.W., W. and N., and in the afternoon N.N.W. and S.W. Upon the 13th in the morning it was S.S.W., W.S.W., and S.W., and in the afternoon S.W., N.N.E., and N.E. Upon the morning of the 14th it was N.E., and in the afternoon E.N.E. and N.E. Now between the 7th and 12th in this period No. 2 Float passed as rapidly upwards as No. 7, and No. 2 Float began to descend with No. 7 Float upon the 17th. Now we deal with Diagram E. In Diagram E. the observations are on two tides, commencing with Float No. 1 at high water on the 16th of October 1882; the observations go on upon the 16th and 17th of October, and the following is the comparison between No. 1 and No. 2 Floats: No. 1 Float is coloured blue, and is at the southern outfall and goes up, while No. 2 is coloured yellow, and starts at Greenwich and goes up; the floats are 8½ miles apart at the commencement; No. 1 Float conforms exactly with No. 4 Float at the same part of the river. No. 2 Float conforms with No. 7 Float. The wind upon the 16th in the morning was E.S.E., and in the afternoon E. and E.N.E. Upon the 17th the wind was N.E. and N.N.E. in the morning, and N.N.E. and N. in the afternoon. No. 1 Float conforms at both the upper and lower ranges; the lower range of No. 2 conforms with the lower range of No. 1; that is where they are both in the same part of the river. Now, taking these A., B., C., D., and E. diagrams, the number of tides which were implicated as being in error, and the number of floats implicated, are as follows:—A., number of tides, 5; B., number of tides, 3; C., number of tides, 2; D., number of tides, 15; E., number of tides, 2; making a total of 27; and the floats implicated are Nos. 1, 2, 3, 4, 5, and 7. The whole of them, except No. 6; but you will observe that upon No. 6 there is no implication, yet No. 3 and No. 5 follow it in parallel lines. Now these 27 tides are but 5·9 per cent. of all the tides in which the observations have been made, but if you deduct the eight tides in the D. diagram, in which it is shown that the two tides were flowing in parallel lines, then the implications only come to four per cent., assuming that they were correct. In all the objections one of the floats is always found in the most crooked part of the river, or between three and ten miles above the northern outfall; that is a very important point. You will find it is invariably in this very crooked part of the river that one of the floats implicated is always found (*pointing on the chart to the curves between Blackwall and Greenwich*), and the wind mostly acts across the river, tending to disturb the tidal current and to diminish the range by driving the float into shallow water or into eddies. The floats explain the action of the river from the very fact that in every one of these objections one of these floats is invariably in that part of the river, and what may appear discrepancies are really due to the influence of that part of the river in checking the progress of the float; butthe whole of the objections form such a very small part of the whole of the tidal observations that, assuming them to be valid, they can throw no doubt upon the accuracy of the general observations.

8252. That is a matter of opinion. Now is that the end of your answer?—That is the end of my answer to your question.

8253. Now, having come to the end of the answer, let us come back to Diagram A. All being said and done, will you tell me now whether it is a crooked part of the river or a straight part of the river; how you account for the fact that in a certain number of tides one float works up and the other works down?—Because, as I have told you, there is an influence which affects all the floats until they pass this crooked part which tends to get them down the river, whilst below this point, and when they have got past it, the tendency is for the floats to go up the river.

8254. Will you condescend to more commonplace language; the progress of these floats is determined by the flow of the water in the river?—Yes.

8255. You put them forward as showing what is happening in the water?—I put them forward as showing what is the oscillation of the tide simply.

8256. Do you believe in these periods referred to in Diagram A., that the water in the neighbourhood of Lambeth Bridge was, upon the whole, flowing up stream, while the water in the neighbourhood of Blackwall was flowing down stream?—I do not mean anything of the kind.

8257. Then you do not say that these floats represent the action of the tide?—I say they show tidal oscillation.

8258. They do not represent what the water did?—I say they represent the action of the particular particles of water just around the floats at the time, but not the general action of the whole of the water in the river.

8259. They do not represent what is taking place in the general body of the river, and therefore they do not represent what is taking place in the general flow of the sewage towards the sea?—I say they do, because wherever the floats have gone the sewage has gone, as is shown by the chlorine tests.

8260. You do not suggest more than this, that it is possible for a particle of sewage to follow the course of one of these floats?—I do not.

8261. Then I will leave that. Now, I take it that a good many of these anomalies are accounted for by the wind?—And tidal currents, which are affected by the wind, among other causes.

8262. By the wind acting upon the float?—Acting upon the tidal currents more than upon the float.

8263. What would be the effect upon a windy day if you made a float fast to the stern of a boat, and so took the float up stream?—It would not have much effect upon these floats; it would be a tremendous job to attempt to haul them up stream; they are so substantial and heavy that it would have little effect upon them.

8264. Just upon another point have you observed an anomaly of another character which I did not observe, so as to call your attention to it upon the last occasion, namely, that upon one particular day, the 29th of October, upon the afternoon ebb tide, the No. 1 and No. 3 Floats behaved in a very remarkable manner, because No. 1 started a couple of miles higher up the river, and ended four or five miles lower down, passing No. 3 at a good pace, and gettting a long way ahead of it; this relates to the same part of the river. No. 1 Float started at high water opposite Deptford Creek?—Opposite Greenwich Station.

8265. And at low water it ended below Greenhithe Pier?—At low water it ended at Messrs. White's cement works.

8266. Below Greenhithe Pier, is it not?

(*Sir John Coode.*) About 10½ miles.

8267. (*Mr. Bidder.*) Now, No. 3, looking at the very same tide, started, did it not, at Blackwall, a point about two miles lower down the river than No. 1, and ended opposite the River Darent, which is some miles above Greenhithe. I think it is called the Long Reach Tavern (*the spot having been pointed out*). Am I right in my facts?—It appears to be so.

8268. What was the point there; was No. 1 in better training?—No. 1, or the one which took the longest range, may have been more in the direct current.

8269. We have got rid of the suggestion that they are in different parts of the river or that different winds are blowing, or that they are in different bends of the river, because they are actually traversing the same part of the river; and the one has made a six

miles better journey of it than the other in the same tide; does that increase your confidence in the reliability of these experiments?—I do not see anything to throw doubt upon them.

8270. (*Mr. Abernethy.*) Were not your floats liable to take the ground occasionally?—Certain instructions were issued with the floats, viz., that the men were not to interfere with them at all unless they got aground; consequently, instead of being driven, as they usually are, right down the tidal way, they were left alone, so that one float might have got into the slack water at the side.

8271. (*Sir John Coode.*) As a matter of fact, they were not frequently interrupted by the men?—I have seen them, when I have been down the river, pulling them out when they were liable to go aground at the side of the river.

8272. Would that state of things be recorded by those who took the observations?—I daresay it would, but when I have been on the river I have seen one float, which was in the tideway, pass one which was in the slack.

8273. (*Mr. Bidder.*) Have you ever seen the float aground, and the two men in the boat comfortably asleep, and anchored to it?—I do not think two men in charge of a boat would be likely to go to sleep.

8274. (*Mr. Abernethy.*) In placing the floats in the river, did you place them in precisely the same point of the river as regards the channel?—When they started; but you will observe that those observations were taken at a very disturbed period of the year, when they were constantly liable to be interrupted by storms, when the water was very rough, and there would be very great likelihood of some of the floats getting into the slack water.

8275. (*Mr. Bidder.*) Before I leave the floats, I wish to ask you another question which arises upon your report. At pages 30 and 31 of your printed report you give certain observations of what you call experimental floats. I thought they were all experimental. But, however, you call these "experimental floats." Now these floats are not tabulated in your final tabulations; am I right in saying this, that the rate of progress of these floats was immensely greater than that of the others?—Certainly, for the simple reason that those floats were ordered to be kept in the full tidal way, whereas the others were ordered not to be touched unless they were likely to get aground.

8276. Those were kept in the full tidal way, both ebb and flood?—Yes.

8277. And, being kept in the full tidal way, they showed a very rapid progress indeed seaward?—Yes.

8278. No. 8 Float, you say, went down upon the first ebb 15½ miles, and only came back 6¾ miles. Upon the next ebb it went down 15 miles, and on the following flood it only came back 11 miles?—Yes.

8279. (*Mr. Abernethy.*) What is the character of these experimental floats as compared with the others?—They were to ascertain the different velocities in different parts of the river.

8280. Were they both the same shaped floats?—They were both long floats, of the same pattern as the others.

8281. (*Mr. Bidder.*) But, although they were designed to show something else, it may be said that they throw light upon this subject too?—And also there is this to be said, that at the time these floats were in the river flood water was in the river, and that would give a greater rate seaward than was the case with the other floats.

8282. I thought you would say that, so I wished to show that your diagram floats upon the same days were not going down the river at anything like the same rate of speed?—They ought not, according to the instructions. The instructions were that the diagram floats were not to be interfered with, but the instructions in the case of the No. 8 Float, now before you, were that the floats were to be kept in the full force of the tidal way.

8283. As regards the tabulated floats, the instructions practically come to this, that if the float got out of the tideway, and were blown, for example, upon one side, and got into an eddy, it was not to be interfered with so long as it did not actually stick on the ground?—That so long as the float was moving down the river, however slowly, it was not to be interfered with, but the length of the float itself was sufficient in my opinion, to prevent its getting into the slacks; for wherever there was sufficient water to swim the float, it would indicate that it was in the fair flow of the river.

8284. But there are points of 12 feet deep in the river where there is a slack?—Yes, but if the man saw his float going aground, he would pull it out.

8285. (*Sir John Coode.*) I think the instructions to the men had better be put in, as we have heard a great deal about them?—The instructions were as follows:—

"The float observations in the Thames are to commence on the 14th September, on the afternoon tide, the first float being placed in the centre of the stream, opposite Barking outfall, on high water at this point, just as the tide is commencing to turn, the exact time the float starts to move down the river being recorded. A peg should be driven into the shore level with the water, and the level of the water should be ascertained at the time the float was inserted. Three hours after the first float has been started, a second float should be started at the same point, and the level of the water should again be ascertained in the same way with reference to the second float. At low water on the same tide a third float should be started, the level of the water and the time being carefully noted. The above-mentioned floats, numbered 1, 2, 3, are to be watched by the persons in the small boats, one boat's crew to have charge of one float and never to lose sight of it, with instructions that if the float gets fouled against any bank or vessel the boatman is to immediately draw the float out into the tidal way, but by no means to accelerate or impede its progress up or down the river. A record must be kept of the times and places at which the floats foul any object. Any doubtful observations should be noted and reported, especially if the floats are observed to make little or no progress in any portion of their course. On the high water of the 14th September the chemists are instructed to draw samples of water, as well as upon the previous low water, so that the float observations must commence on this particular tide. On the 22nd September, being neap tide, upon the high water in the afternoon tide of that day, the second series of float observations will commence off Barking, the floats being numbered 4, 5, and 6, and these will be placed in the charge of men in small boats with instructions similar to those before given. Each boat must carry small supplementary floats, and in case of the detention of the larger float the smaller float must be put into the river at once. Spare floats of the larger type must be stored at known points, so that in case of accident the larger floats can at once be replaced; but in all cases, awaiting the procuring of the larger floats, the small supplementary floats are to be used to keep up the continuity of the observations. It will be necessary when the men change from day to night work that there should be some system of recording the position of the boats, so that when an exchange takes place the fresh men may know at what point to meet their boat. Under no circumstances are one set of men to leave a boat until the relief men have entered upon their work, and on no account are the men, especially at night, to lose sight of the floats in their charge. While these experiments are going on, and the steam tug is not required, observations upon single tides should be going on in the mouth of the Thames, first with a view to ascertain at every state of the tide how far the tide flows up the river, for which purpose every day for the first fortnight a float or a couple of floats may be put in the water at extreme low water off Southend Pier; and secondly, it is desirable to know the point in the Thames where, if the sewage is

*Mr. B. Latham, M. Inst. C.E.*

6 Feb. 1883.

discharged every 1, 2, 3, 4, or 5 hours after high water, sewage would pass out to sea. This may be ascertained by putting in floats in different positions in the lower part of the Thames so as to get these results. The experiments with the floats at low water will give approximately a point near which anything admitted at high water would all pass outwards. It is also desirable that experiments should be made to ascertain whether, if the floats are carried out to sea from the Thames, they are likely to be brought back by the succeeding tide into the river again. For this purpose spare floats numbered 7 to 12, when not required for other experiments, may be used. These latter observations need only be carried on on single tides, and the information may be got in the day tides. The observations must, however, be carried on when the tides are making as well as when they are falling. The direction of the movement of the floats outside the river should be shown on a chart."

8286. (*Mr. Bidder.*) Now these instructions do not quite carry out what you say they did, because you say the men are never to lose sight of the float, and are only to interfere with it if it gets fouled against any bank or vessel, then they are to draw it into the tideway; but if it gets into an eddy, there are no instructions?—But there is an instruction that it is to be noted if it makes very little progress in its course.

8287. Have you recorded any instance of that?—I have no doubt it is recorded.

8288. Again, if a float fouls a vessel, it is to be drawn into the middle of the tideway?—Yes, if a float fouls a vessel, it is to be drawn into the tideway, certainly.

8289. So that another contingency comes in, it depends upon how many times the float has come into collision with a vessel, how many times it has been drawn out into the middle of the river?—We have had one float smashed by coming in contact with a vessel.

8290. So that, as regards No. 1 Float, I draw your attention to the fact that No. 1 Float had been very fortunate in coming into collision a great many times and being put frequently into the middle of the river?—That would not have been the reason of its progress; it was in a very stormy season, when there would not have been many vessels going up and down.

8291. I will now leave that part of the case and pass to the chlorine tables, and ask you certain questions about them, and about certain tables which you handed in, showing the effect of the mixing action. I have before me that table in which you gave the area of the cross section of the river at different points, and the ratio of river water and sewage combined to sea water. I think that has been handed in to the Commission?—There are two tables of the kind.

8292. I want to see how much of this is fact, and how much is inference; as regards the area of the cross section, that I believe is matter of calculation from the plotted section in the ordinary way?—Yes, that is the area taken out by Mr. Mansergh.

8293. Now, as regards the rest, namely, the question of what are the relative proportions of water and sewage and sea water, and consequently the sectional area occupied by each, and the time of flowing down the river, those are matters of inference, are they not?—Those are calculated in the way which I have already explained very clearly upon the notes.

8294. The observation upon which the calculation has been based being that at each of those places you took a sample of the water of the river and then ascertained that there were so many grains of chlorine in it?—You are not right in saying "a sample"; in every one of those cases a large number of samples were taken across the surface and at 20 feet in depth, and this is the average of all the samples at every point; it is not one sample, it is the mean result.

8295. From these samples you have obtained so many grains of chlorine in a sample?—Yes.

8296. Then you reason, assuming that sea water contains 1,961 parts, and sewage 10, and the water of the River Thames 1·7, as to in what proportion the two are compounded at that place?—Yes, exactly, those being the figures absolutely known to be the amount of chlorine in those descriptions of liquid.

8297. To begin with, you have to make an assumption as to what is the proportion of sewage to river water, have you not?—Certainly, and I have already told you that the sewage has been taken at the standard estimate of five cubic feet per head of the population.

8298. You assume in each case that there was such a proportion of sewage; so many million gallons of sewage and so many million gallons of river water coming over Teddington weir upon that day?—Such a quantity of water coming into the river at different points, not only at Teddington.

8299. Take, for instance, that 14th of September, and for illustration I will take the result at Crossness, where you say there is a ratio of 1·14 river and sewage water compared with the amount of sea water?—Yes, at high water.

8300. Is not the ratio between the river and the sewage water derived from assuming that there was the amount of sewage you have stated from the population, and that amount of river water which your tables show coming over Teddington Weir, and from the other tributaries upon that day?—Yes, I said so.

8301. Is not that necessarily erroneous for this reason, that the river water which came over Teddington Weir upon the 14th is not the quantity that is mixed down at, say Crossness, upon that day, and would not be mixed down at Crossness for several days to come?—But I do not admit it to be an error, for according to the theory of impulse, whatever is put in at the upper end would push out an equal volume at the lower end of the river.

8302. Do you mean to say that, if we suddenly alter the volume of the water that went over Teddington Weir, that would produce an instantaneous alteration at Crossness?—Yes, or very shortly in proportion to the speed at which the impulse can travel. If you put a quart of water into the upper end of a long channel or a short channel, a quart will speedily run out at the lower end.

8303. So you consider that you are justified, however many miles there are from Teddington Weir to Crossness, in adopting the quantity of water coming in at Teddington Weir as representing an equal quantity of river water all the way down the river?—Yes, I am justified in that.

8304. You say that sewage water contains 10 parts of chlorine to 100,000?—Yes.

8305. Are you aware that it contains over 20?—No, I am not.

8306. Where did you get the 10 parts in 100,000 from?—Our chemist gave us the figure; it is the generally accepted estimate.

8307. At any rate you would admit that if it contains 20 instead of 10 parts the whole table would be vitiated?—Not at all; it would have to be modified to that extent; but the difference between whether it is 10 or 20 when mixed with river water, and 1,961 is very slight.

8308. You mean to tell the Commission that, in estimating the amount of river water and sewage in any part of the river by the chlorine, it matters very little whether you take 10 or 20 parts to 100,000 of chlorine in sewage?—Certainly.

8309. Do you tell the Commission that it is of very little moment in making these calculations whether there are 10 or 20 parts of chlorine to 100,000 in the sewage?—I have a table here which shows the result, supposing that there was no sewage in it at all.

8310. I would rather not go into another table unless it is absolutely necessary?—I say that when you get to the lower parts of the river it will make very little difference indeed.

8311. (*Chairman.*) The ratio would be 10 to 1,961 in one case and 20 to 1,961 in the other?—Yes, but the volume of the sewage is very much smaller than of the tidal water.

8312. (*Mr. Bidder.*) So that in each of those calculations you made two assumptions. Having said, for instance, that there were four grains of chlorine in a particular sample, you said, "I first assume that "what fresh water there is is, in a certain proportion, "river water and sewage, and then I next assume "that the sewage has 10 grains of chlorine in "100,000 parts"?—Yes. Will you allow me to inform you that according to the calculations as they now stand the initial quantity in the river is 1·7, and that at Barking, with the sewage added, that 1·7 comes to 2·42; that is, with the 10 grains of chlorine in 100,000 parts.

8313. You have not worked the calculation out by the 20?—No, but you will see that, if taking it at 10 parts only increases it by 0·72, the other would only further increase it by 0·87, which would bring it to 3·29, so that the amount of chlorine, instead of 2·42, would be 3·29 in 100,000 parts.

8314. That is pretty well to begin with?—But that will come to a very slight difference when you come to the open part of the river.

8315. I began the other day to compare another table you put in with the series on the blue paper at page 6. I was drawing your attention the other day to this, that, looking at the two tables (I will take the same illustration I took the other day) at St. Paul's Pier upon the 14th September at low water, your first table represents the ratio of water and sewage combined to sea water as 983 to 1?—Yes.

8316. The table No. 6 on page 6 of the blue paper upon the same day, at the same low water, and at the same place, St. Paul's Pier, represents the ratio of upper river water to Southend water as 803?—Yes.

8317. And I think the other day you accounted for the difference by saying that in one case the comparison was to sea water, and in the other case it was to Southend water?—Yes.

8318. So that, to begin with, you can vary the figure from 803 to 983 by saying that it was Southend water instead of sea water?—And in the first case it was river water with no sewage in it. Reading the head of the table, it will be as clear as possible.

8319. I wanted you to fall into that trap, and you would not the other day. Then let me draw your attention to a very curious thing. Am I to assume that the difference between the 803 and the 983 represents the sewage?—No, do not assume anything of the kind.

8320. Then how do you account for this, that, whereas at low water there is that enormous difference, if you look at the same place at high water, the ratios vary very little?—Exactly; because in the one case the river water is taken at low water, and in the other case at high water when it is nearly all tidal water.

8321. But comparing the two tables at low water, there is an enormous discrepancy between the results of the two tables, one being 983 and the other 803; but at high water the discrepancy is almost imperceptible?—I want to explain that, if you take the figures and work them out by the formula I gave you, you will find that both figures are absolutely correct. I have worked them out, and they show the correctness of the result.

*The following paper was handed in:—*

On Sept. 14th the amount of chlorine in the sample at high water was 210·7.

On Sept. 14th the amount of chlorine in the sample at low water was 4·1.

In one case "a" the amount of chlorine in tidal water = 1931.
and "b" " " river " = 1·7.

In the other case "a" the amount of chlorine in sea water = 1961.
and "b" the amount of chlorine in river water and sewage combined = 2·11.

$\frac{a-c}{c-b}$ in one case $= \frac{1931-210{\cdot}7}{210{\cdot}7-1{\cdot}7} = \frac{1720{\cdot}3}{209} = 8{\cdot}2$ { the ratio of river water to tidal water.

$\frac{a-c}{c-b}$ " $= \frac{1931-4{\cdot}1}{4{\cdot}1-1{\cdot}7} = \frac{1926{\cdot}9}{2{\cdot}4} = 803{\cdot}$ do

$\frac{a-c}{c-b}$ in the other case $= \frac{1961-210{\cdot}7}{210{\cdot}7-2{\cdot}11} = \frac{1750{\cdot}3}{208{\cdot}59} = 8{\cdot}4$ { the ratio of river water and sewage combined to sea water.

$\frac{a-c}{c-b}$ " $= \frac{1961-4{\cdot}1}{4{\cdot}1-2{\cdot}11} = \frac{1956{\cdot}9}{1{\cdot}99} = 983{\cdot}$ do.

8322. If the discrepancy were due to taking the Southend water instead of the sea water, it would affect both parts of the table equally?—But you observe that in one case you have not only got Southend water at one end of the river, but you have upland water at the upper end of the river. The object of the table was to show what would be the effect of mixing these two waters, totally independent of sewage or anything else, which would be going down the river, and then it shows you that when you come to high water there is very little difference indeed in the mixing action in the river. In one case the proportion comes to 8·2, and in the other case to 8·4, but they are both absolutely correct.

8323. But you do not quite understand the point of my question. At high water at St. Paul's Pier the two tables are very nearly identical in the ratios which are given, viz., 8·4 and 8·2?—Certainly.

8324. At low water the discrepancy between the two tables has become very great, and, inasmuch as in both cases the difference of Southend and sea water affects the two tables in the same ratio, it must be due to the sewage that the discrepancy is increased?—That is one of the causes, there is no doubt.

8325. Then it seems to show there is more sewage at low water at St. Paul's Pier than there is at high water?—No, it does not show anything of the kind.

8326. Now I will ask you another question. Seeing that it is Southend water that comes up the river, and not pure sea water, would not the Southend water have been the more reliable and proper standard to have taken in this other table rather than sea water?—No, it would not, but as a matter of fact, you will see how small a difference there is; you will see that the tidal water there, for the purpose of calculation, is taken as containing 1,931 parts of chlorine at Southend upon the 14th instead of 1,961.

8327. Where is that?—That is in the chlorine table itself; the quantity given by the chemist is 1,931 in 100,000 parts at Southend as against 1961 parts in sea water.

8328. Then, in point of fact, the difference between sea water and Southend water has nothing to do with it?—I have already told you that it has.

8329. The difference is very minute?—It only shows that by taking that quantity at any particular time the tidal water at Southend differed very little from real sea water.

8330. Then if that be so, it must be the presence of the sewage which accounts for the difference?—I have already told you that the sewage accounts for a quantity of the chlorine in the water.

8331. At page 4 of your tables you give another analysis with regard to chlorine. I will now ask you a question to see how far this method of yours is trustworthy. The table is headed "Chlorine in 100,000 parts of Water," at different places. One very startling result to which I draw your attention there is that upon the 30th of November the sea at Margate had 1,770 and 1,735 parts of chlorine, and I think it would follow that, according to your calculation, the sea at Margate was 10 per cent. sewage and river water. The application of your process of inference, if it is a trustworthy process, leads to that conclusion, does it not?—It does not follow at all.

8332. If your sea water is 1,961, applying that same process to the other table, does not it come to that?—No, it shows that the sea water even there was very diluted from some cause or other; but whether it was sea water, or whether it was anything else, it does not show; it might have been pure river water which was mixed with the sea water.

8333. So that your standard of 1,961 might have been incorrect?—No, it is admitted by the generality of chemists that that is the standard of sea water.

8334. Only that, as the Thames is fed at flood tide from the sea at its outlet, it shows that the Thames at its outlet may differ from the standard?—That shows that the sea was very diluted at that point on that day.

*Mr. B. Latham, M. Inst. C.E.*

6 Feb. 1883.

8335. That shows that the sea water when it gets into the Thames may differ very far from your standard?—It only goes to show that the Thames influences this water at Margate to a very great extent, and that the tidal water coming in is very largely the water that has gone out of the Thames previously.

8336. Now I go to another point upon which I wish to ask you a few questions; you told the Commission that Sir Joseph Bazalgette's scheme of main drainage as carried out was designed for, and equal to, a population of 500,000 less than that which now exists?—That is according to the figures in your own report.

8337. The population, correctly given from the Registrar-General's Returns, is shown in your table as 3,800,000 and odd, but are you aware that of that population a certain proportion not only does not drain into the Metropolitan drains, but drains in other directions, and always will?—What portion may I ask are you referring to, which always drains in an opposite direction?

8338. Are you aware that a part of the population within the Registrar-General's area of the Metropolitan District does drain in other directions, and does not drain into the Metropolitan sewers at all?—I am aware that within the Metropolis there are a very large number of drains into the Thames, the sewage of which does not go into your sewers.

8339. Are you aware that a part goes into the West Kent drainage?—I am aware that you have power to put it in, but that is a very sparsely populated district, and that is beyond the area of 40 square miles on the south, which is included within your limits.

8340. I am doing my duty if I ask you whether you are aware that we have such a power?—I am aware that you have such power, but I am not aware that a drop of your sewage goes into that West Kent system; the district is very sparsely populated and is nothing as compared to the general population.

8341. When you speak of what Sir Joseph Bazalgette designed his works to carry off, as compared to what they are doing, is it not the fact that in designing these sewers for three and a half million people it was estimated that they would have to deal with a maximum flow, which was double the average flow?—I have already told you.

8342. I wish you would not say that you have already told us everything?—I have said that you calculated the sewage at five cubic feet per head, half of which was to flow off in six hours, and that, as shown by the southern gaugings at Crossness, instead of half the sewage flowing off in six hours, it flows off on that side in nine hours.

8343. Now will you answer the question: were the sewers designed upon the assumption that the maximum flow would be double the average flow?—They were designed upon that assumption in certain districts; in each separate district.

8344. Was the whole system designed upon that assumption?—I have already said that the northern outfall sewer was half made before the western sewage was taken there, and therefore, to the extent of the western sewage, the northern outfall is not large enough.

8345. Were not those sewers designed upon the assumption that the maximum flow they would have to deal with would be twice the average flow?—Down to Abbey Mills they were designed upon that assumption.

8346. I am not talking about whether the western district was taken in or not. I am asking you whether the maximum to be dealt with was not in the ratio of two to one of the average?—It is impossible to answer the question unless you take into account the western district sewage.

8347. (*Chairman.*) Do you know upon what assumption they were designed?—I have already stated that the assumption was five cubic feet per head per day, half to flow off in six hours.

(*Mr. Bidder.*) Does experience show that the maximum flow is only 40 per cent. greater than the average flow?

(*Mr. Lumley Smith.*) You mean the maximum flow through the sewers.

(*Mr. Bidder.*) Yes.

(*Witness.*) I cannot say whether that was so or not, for this reason, that we have only got the gaugings upon the south side, and I have shown you that the gaugings upon the south are 50 gallons a head, instead of 30 gallons a head, and we have nothing to guide us upon the north, except the figures given us by Sir Joseph Bazalgette, which I have already analysed, and have shown what an immense difference there is between the figures for the north and the figures for the south.

8348. (*Mr. Bidder.*) Do you know that the maximum flow is only 40 per cent. greater than the average flow?—Upon the south.

8349. And upon the north?—How can I know what it is upon the north?

8350. By examining the figures, which have been supplied?—There have been no figures supplied for the north, and I have given you the figures for the south.

8351. If that be the fact, the sewers which were sufficient to carry off the sewage of three and a half millions, upon the assumption that the maximum flow was double the average, would be equal to carry off the sewage of a very much larger population upon the assumption that the maximum is only 40 per cent. greater than the average; would not that be so?—Yes; but you must bear in mind that by reason of the very large amount of leakage into the sewers upon the south the flow is rendered more uniform on that side.

8352. You found, you say, an enormous leakage into the sewers upon the south?—Yes.

8353. How did you deduce that leakage?—I took it from the figures which you put in in the Mud Inquiry, showing that in the driest period we have ever known, namely in July 1876, although the water supply was 30 gallons a head, yet, during the same period the flow from the sewers was 50 gallons a head, showing that the leakage was equal to 20 gallons a head per day.

8354. Would you be surprised to hear that it was the practice of the Metropolitan Board of Works to let water from the Thames into the sewers in order to flush them?—I think it would be very curious if they were doing so at the time when they were making gaugings to ascertain what the flow of the sewage was.

8355. Are you aware that that is the practice?—It would seem very curious to me if as you say they were doing it then.

8356. If that is so, then that would destroy your inference?—If, at this period, they were letting in 20 gallons per head from the Thames, then that would modify the inferences very much, but I should be very much surprised if at the time when they were making those observations they were doing so.

8357. Now I pass to the tables, showing the population and death rates of certain places; viz., Barking, Grays, Dartford, and Gravesend; can you give the Commission any idea of what is the area and the position of the districts which in the Registrar-General's Tables go by those names?—They can be got; there is a plan published showing them.

8358. Are you aware that some of the districts go far inland and include populations remote from the places from which they take their names?—Yes.

8359. You are aware that those include populations which are not riverside populations?—I stated that those were registration districts; there are plans published in the Census returns which show the whole of them.

8360. Dartford is really close by the river, but the Registrar-General's Dartford goes far inland?—Dartford itself is upon the Darent, but Erith in the Registrar-General's district is included in Dartford.

8361. The district goes inland three or four miles? Yes; the district goes inland to a considerable extent.

8362. Is that idea of adopting the ratio of the births divided by the deaths an original one of your own, or has it the sanction of any sanitary authority? I have not seen it, except in my own hands.

8363. Have you ever heard it adopted or suggested by anybody before this inquiry?—No; but I have used it myself for years.

8364. Was it invented for the purpose of this inquiry?—No; nothing of the kind.

8365. Not discovered for the purpose of this inquiry?—Nothing of the kind; I say I have used it for years.

8366. It never occurred to anyone else?—Perhaps it has never occurred to anyone else.

8367. Now, with regard to the temperature, what is your warrant for saying that the Thames becomes offensive in a temperature of about 65°?—I put it between 65° and 70° from the evidence of the most eminent chemists, who have stated that at that temperature putrefaction and fermentation are most active.

8368. Where is the evidence of the eminent chemists who state that at that point putrefaction or fermentation begins?—You will find that there was a good deal of evidence upon that point given before the Select Committee of the House of Commons in 1858.

8369. Would putrefaction or fermentation begin with a temperature of 65°?—No; I do not say that, but I say, assisted by a high temperature of the mud.

8370. You stated specifically 65°?—I stated from my own information that the river becomes offensive with rapid fermentation at from 65° to 70°. It was the evidence which was brought before that Committee of 1858 with regard to the state of the River Thames which drew my attention to it, in which it was shown that the temperature of the water was then 70°, and the temperature of the mud was 120°.

8371. I do not think that that shows it?—Simply by analogy, that the river was more offensive that year, when it had been very warm for some months and for a longer period than it had been in previous years, and it was a very dry year as well. There is one reason I ought to mention, why the Thames becomes so offensive in summer time, viz., that in the summer time there is a very large amount of mixture of salt water with the Thames water and the sewage, and whenever sewage and salt water mix together they produce the most offensive compounds, and of course the drier the period the more salt water there is in the river. In fact so potent is this influence that in Messrs. Bazalgette, Bidder, and Hawksley's Report of 6th April 1858, at page 32, they actually point out that if the Government Referees discharged the sewage of London at Mucking Lighthouse which they proposed, it would seriously incommode Gravesend, which is seven miles distant. Now, in summer time, the sewage is discharged at Barking and Crossness into the river, which is then quite salt, and consequently must create the most offensive effluvia at that particular period.

8372. You have made a very extensive excursion, how does this show that 65° temperature produces this offensive smell?—Because at that time, in dry weather, there is a very much greater tendency for the salt water to come up the river.

8373. (*Chairman.*) You mentioned 65°, is that the result of your own observation, or is it taken from some authority of chemists?—I have always said that it was after 65° and up to 70°.

8374. Is that the result of your own experience, or did you take that as a fact from somebody else?—It is the result of my own experience, but with regard to the Thames, I specially referred to the temperature which was brought out in 1858 before the Committee referred to.

8375. (*Mr. Bidder.*) As I understand you, in summer time in dry weather, there is a larger proportion of sea water in the river?—In July, to which the Report referred, there is, owing to the dry weather, a larger amount of sea water.

8376. Is not July the second wettest month in the year?—There is a large amount of rain water which falls, but it does not run off except from the roofs, and the roads, and the sewers.

8377. Now you gave certain figures with regard to the weight of solid matter in suspension in the sewage, which you said you took at 3½ oz. per head of the population?—Yes, for everything.

8378. And that works out to how many tons in the year?—132,000.

8379. Are you aware that that is wet and not dry?—I have already explained clearly to you that that included all the solids both in urine and in fæces, and, in addition, any solid matter which went into the sewers.

8380. Do not you know that the solids in urine are solids in solution and not in suspension?—I told you that that particular 3½ oz. I laid no stress upon; it was only in corroboration of the general calculation.

8381. Now I will draw your attention to the evidence of Dr. Frankland upon this point, and ask you whether you agree with it; at page 462 of the evidence given on the Mud Inquiry, oddly enough, Dr. Frankland gave almost the very same figures as you,—130,000 tons per annum; and I see he was cross-examined by myself upon that point. I will not read it all in detail, but you will see at Question 4531 in answer to Mr. Bramwell, who said, "52,000 "tons I make it," he says, "Yes, of course, 52,000 "tons dry, if the present statement is correct, becomes "130,000 tons wet, that is the difference.

"(*Mr. Bidder.*) There would be 60 per cent. of "water in that.

"(*Mr. Bramwell.*) It comes to 52,000 dry, does it "not?" 52,000 is a misprint,—it should be 32,000. Then at Question 4533, I say, "There are a lot of "gentlemen behind me who suggest that you under-"state the quantity of water in fæces when you speak "of 60 per cent.; it is more like 75 per cent.?—"(*A.*) I do not think that there will be more dis-"crepancy about the percentage of water in wet fæces "than the percentage of water in those mud banks. "(*Q.*) But, however, we are turning fæces into dry "matter?—(*A.*) Oh, very well. (*Q.*) Then I must "take a fourth?—(*A.*) You may take a fourth." Now if you divide the 130,000 by four, that is exactly 32,000 and a small fraction. Then says Mr. Bramwell, "Does that 75 per cent. allow for the urine? "(*Mr. Bidder.*) No, the urine is a different part of "the question. I really do not know that it matters "in the least. (*Q.*) But as a fact your 130,000 tons "becomes 32,000?—(*A.*) It shows the danger of "going from one's analytical results and calculating a "thing theoretically. I have mistaken the wet for "the dry; there is no doubt about it."

(*Mr. Lumley Smith.*) That is excluding the urine.

(*Mr. Bidder.*) Certainly, because the salt in the urine are matters in solution and not in suspension.

(*Witness.*) I say I laid no stress at all upon the 3½ oz., but since the last sitting of the Inquiry I have looked into the matter, and I find at page 132 of Dr. Letheby's book, published in 1872, entitled "The Sewage Question," he shows the total of the soluble organic matters.

8382. (*Mr. Bidder.*) But that is "soluble"; we are talking about suspension?—Dr. Letheby gives you the total amount of solid matter from excreta and other refuse, and he gives, as a matter of fact, suspended matter too; he makes the solid matter come to 0·2044 of a lb. That agrees as nearly as possible with my 3½ oz.

8383. But you are taking wet for dry?—Not at all. I have told you distinctly that the 3½ oz. includes all matter in suspension in the sewage.

8384. Does Dr. Letheby say "dry"?—Yes, this is the actual matter in the water that he gives you. Then again, in that book there are no end of examples

*Mr. B. Latham, M. Inst. C.E.*

6 Feb. 1883

where very much larger quantities of suspended matter are found in sewage than I have given you.

8385. You know that the solid matter would be accounted for to a considerable extent by the road detritus.

(*Mr. Lumley Smith.*) At question 7903 you will find that Mr. Latham spoke of dry matter, not of solid matter.

*Dr. Letheby's book having been examined by Mr. Bidder.*

8386. (*Mr. Bidder.*) You have quoted this book of Dr. Letheby's in confirmation of your statement that the dry matter of fæces was equal to your 3½ oz.; and you referred me to the figure of 0·2044 of a lb.; did it not appear upon the face of the book, that only one-fifth of that was from excreta, and four fifths from other sources?—Certainly. I did not say anything else.

8387. You quoted that book in confirmation of your view upon the dry matter of fæces; did not the book tell you, upon the face of it, that only one-fifth of that dry matter was from fæces?—What I gave was in corroboration of my own estimate. As I said in the case of Croydon it was found that one-tenth of a lb. per head per day was taken out by my sewage extractor, and then there was one-tenth of a lb. which went on to the sewage farm, that gave one-fifth of a lb. of solid matter per head per day in the sewage, and on referring to the solid matter in the sewage found by Dr. Letheby he gives you a little more.

8388. I was cross-examining you as to the amount of solid matter in fæces, and I put it to you that the amount you allowed was a great deal too much, and you quoted that book of Dr. Letheby's as showing 0·2044 of a lb. as being solid matter.

(*Sir John Coode.*) The words I took down were "one-fifth of a pound per head per day solids in "sewage."

(*Dr. de Chaumont.*) It would save time if we understand the matter distinctly; at present we are looking at it in two different ways; as I understood the witness, he said that the total amount of solid matter reduced to complete dryness was about 3½ ozs., but I did not understand Mr. Latham to apply that at all to fæces. It so happens that the average amount of fæces is just about that weight, but including 75 per cent. of water so that there would be something less than an ounce of dry fæces, and the remaining two ounces odd would be the soluble solids in the urine; that was what I understood Mr. Latham to say, is that right.

(*Witness.*) That is quite right.

(*Mr. Lumley Smith.*) The witness said the other day part was in solution.

(*Mr. Bidder.*) You understood Mr. Latham to mean 3½ ozs., including what was in solution. But if you look at the figure, this is the figure relating to what is in suspension. Dr. Letheby says it is true one-fifth of a pound, but he goes on to say that only one-fifth of that is from human excreta, the remainder is from other sources, road detritus, and so on.

(*Sir John Coode.*) The witness says that the amount of dry matter produced per head of the population is 3½ oz. of fæces.

(*Mr. Bidder.*) That is dry matter, and he quotes the book in front of him in support of his figure.

(*Witness.*) I quoted that book in confirmation of the estimate I gave upon the last occasion of the 3½ ozs., as the total solids in the sewage, and I have told you over and over again that these 3½ ozs. have nothing to do with the calculation.

(*Mr. Bidder.*) If you will look at question 7906 there is no doubt about it, because he was asked this question in his examination in chief: "So that your "view is that of fæcal matter alone you get 138,000 "tons, and of general solid matter 197,000 tons," to which the answer is "Yes."

(*Mr Lumley Smith.*) But you must take that with the 7902, which he explains would be made up with other matters.

8388*a*. (*Chairman.*) That would give about one-fifth of a pound for each person?—Yes.

(*Chairman.*) And this table in Dr. Letheby's book shows that there would be one-fifth of a pound of suspended matter for each person.

(*Mr Bidder.*) The table shows that there is one-fifth of a pound as suspended matter, but only one-fifth of that is fæcal.

(*Witness.*) You will recollect you asked me that question, and I declined to answer it. I said it was a question for a chemist, and not for me to say what was soluble, and what was organic matter.

8389. (*Mr. Bidder.*) You have given a great many figures to the Commission with regard to the quantity of sewage, and the ratio of the mixing action, and mixing with the sea water, and so on; now is it not the fact that the sewage when mixed with sea water rapidly disappears as sewage altogether?—It undergoes certainly a rapid decomposition.

8390. And your tables, based upon the assumption that the quantity of sewage put into the river still exists as sewage, are fallacious? — They are not fallacious because I have been most careful to put them together so that there should be no division. I have put in the words "sewage and river water combined," because I knew directly that if I attempted to separate them I should be told that it had disappeared as sewage, therefore I combined them in all the tables, and I show from the tables the rate at which the combined upland water and sewage water pass out of the river together.

8391. But your tables show a certain amount of sewage which you get from observations, and a certain amount of sewage which you know from gaugings comes out of the sewers?—Yes.

8392. But that which comes out of the sewers when it mixes with the sea water rapidly ceases to exist as sewage?—Yes, but that part which we have taken as chlorine is indestructible.

8393. The tables are based generally upon the assumption that there are so many million gallons of sewage coming in at Barking and Crossness, and mixing with so many millions of gallons of water coming over Teddington Weir, and from the other tributaries, and the ratio is based upon that?—The ratio of the chlorine of these samples.

8394. But as sewage you admit that a great part ceases to exist after a time?—I am quite ready to admit that the action of the river is to destroy certain parts of the sewage.

8395. I put it to your experience as a sanitary engineer whether the discharge of the sewage into a tidal river, where it mixes with sea water, is not the safest way of disposing of it?—I do not agree with that.

8396. (*Mr. Abernethy.*) Were you acquainted with the sewage of Brighton formerly?—I do not know much about the sewage works of Brighton, but I have had much experience in the sewage works of sea coast towns, and I know that in some cases the outfalls have been a most frightful nuisance.

8397. Discharging into the sea direct?—Yes.

8398. (*Mr. Bidder.*) That is to say, where you have an outfall which does not take the sewage sufficiently out to sea so that the solid matters are thrown up upon the beach and make an offensive odour?—But in a tidal river like the Thames there must be many days accumulation in the river, which must create a nuisance. I have taken the trouble since the last meeting of the Commission to find out what would be the time during which, owing to the mixing action, the sewage and upland water would remain in the river, and we find that there is an absolute proportion between all these three observations which tends to confirm the correctness of the observations themselves, and it differs very little from a well known hydraulic formula. We find that the length of time is inversely as the seventh root of the fourth power of the quantity coming down the river, consequently in a dry time, when there is only 12 cubic feet coming from a square mile, it would take 63 days for the

sewage to get out by mixing, therefore you would have 63 days accumulation of sewage in the river in a very dry time.

8399. Is it not the fact, where you discharge so that the sewage has the opportunity of mixing with the sea water, that owing to the moving of the water, that is, the action of the motion itself in destroying the organic matter, that forms a perfectly safe method of disposing of the sewage?—I do not say it is always safe; I have mentioned already that one of the objections to the discharge of sewage by means of outfalls into the sea is the frightful nuisance they sometimes create.

8400. Have you ever seen a book called "Sanitary Engineering," by a gentleman named Baldwin Latham?—I know the book well.

8401. I will read a passage to you; it is from page 456. "It may be said in reference to sea out-"falls, that owing to the great mass of water into "which the sewage is ordinarily discharged, and also "owing to the more or less constant movement of "the water, and to the action of the sea water itself "in destroying organic matter, this mode of disposing "of sewage is perfectly safe from a sanitary point of "view, and every trace of sewage discharged under "suitable conditions into the sea soon disappears." I had better read on, as there is something more which is to the point. "When we know by actual experience "that the most perfect mode of dealing with sewage "so as to purify it will not remove more than 80 per "cent. of the impurities present, it is clear that if "one volume of sewage were mixed with four "volumes of water containing no sewage, the mix-"ture would be equal in purity to the purest sewage "effluent. In a sea outfall the proportionate ad-"mixture would be much greater, and is sufficient to "produce the effects of purification observed under "some of the most favourable conditions for securing "a pure sewage effluent." I will just follow that up by asking you, whether at Barking and Crossness the proportion of pure water to sewage is very much greater than three or four to one?—No; there is no pure water at all there.

8402. You stand upon the word "pure." I must admit there is no pure water at all there?—But you know that you have to discharge upon the top of the tide, and the previous sewage has only finished discharging three hours before you discharge again, so it is quite clear that the last sewage that was discharged, must have gone up six miles above the outfall, and therefore, when you discharge on the next high water you actually discharge just upon the top of the previous volume of sewage.

8403. Have you ever taken the trouble to ascertain what the proportion is of sewage to pure water, so to call it, in the Thames at Barking and Crossness, and other parts?—I have given some attention to the matter.

8404. What proportion does a day's sewage bear to the sectional capacity of the part of the river in which it is discharged?—But I should like to answer the question about this quotation first.

8405. Have you anything to qualify the view which you have expressed in that book?—I would first of all desire to observe that this is the concluding passage of a whole chapter upon sea outfalls.

8406. I suppose it is intended to sum it up?—No; I had been pointing out in this chapter the difficulties which often arise with regard to sea outfalls; as you will observe, I had been dealing with the difficulty of solid matter when likely to be deposited. You find first of all that at page 446, I draw attention to the influence of the eddy tide, and show that anything cast within its influence will be deposited upon the shore, then I refer to the influence of sand banks, and then I draw attention upon page 447 to the improper position very often of sea outfalls.

8407. And having said all this, you sum it up by saying what I have read?—I have not finished yet. Then I draw attention to the fact that floating matters and fatty matters are blown back to the shore by the wind. Then I show the damage that is likely to arise to the fisheries from the discharge of sewage. Then you will see that I deal with the action of sea water, especially in setting up decomposition; then the importance of the protection of sea birds, which are the scavengers, which carry away floating matter, and then you will find that this is a sort of reassuring passage to the effect that there may be cases in which sea outfalls properly constructed may be carried out; but you will observe with regard to this mixing, that the solid matter cannot be subject to the mixing action.

8408. Having said all that, is this true or not?—It is perfectly true as far as it goes.

8409. (*Chairman.*) You say they "discharged under suitable conditions into the sea"?—You will observe, as I have previously stated, that the mixing action does not affect the solids; a shrimp is a shrimp whether he is in a pint or a gallon of water, but a pint of salt water or a gallon of salt water, and a gallon of distilled water mixed together make very different mixtures, and my evidence has applied to the solids in suspension. You must not take an isolated passage like that and read it; you must take it with regard to the bearing of what has been said before. Qualified in that way there is not a word in that book which I wish to withdraw, but now that you have brought the book in evidence, I think it would be very desirable if you would draw attention to the part relating to the effect of the rainfall upon the Metropolitan sewers.

8410. (*Mr. Bidder.*) I must ask you to confine your evidence to the passage upon page 456. It is true, is it not, that where you discharge sewage into sea water, and mix it, the decomposition makes it rapidly disappear?—Yes; and creates a frightful nuisance under many circumstances, while it is going on, and in the second place, with regard to the purity point, there is no pure water in the Thames for it to mix with.

8411. But at the same time this is not inconsistent with its being perfectly safe in a sanitary point of of view?—If all the conditions are observed which are set down here.

8412. What is essential, is it the proportion?—It is essential that the sewage shall be effectually got rid of.

8413. But what can be more effectually getting rid of it that getting rid of it by decomposition?—But that is a slow process. If you select a tidal outfall at the proper point it is got rid of at once, but if you put it into the river it is washed backwards and forwards.

8414. I suppose it is the fact that one part of sewage and four of pure water is equal to the purest sewage effluent?—That is taken from the 1st Report of the Rivers Pollution Commission (1868), when they were dealing with the proportion of sewage matter removed.

8415. (*Chairman.*) You mean after the precipitation of the solids?—That is only relating to matters in solution; no amount of mixing can affect the amount of solids in the sewage.

8416. (*Mr. Bidder.*) But you had better keep your eye upon the paragraph because you are getting adrift from it; you say, "We know by actual ex-"perience that the most perfect mode of dealing "with sewage, so as to purify it, will not remove "more than 80 per cent. of the impurities present." there is nothing about matters in solution there?—No; but I have already pointed out that I had dealt with matters floating upon the surface and other solid matter.

8417. But matter floating upon the surface is not matter in solution?—Certainly it is not.

8418. Now you have mentioned the proportion of the mixture of four to one of pure water and sewage as being equal to the purest sewage effluent; what do you say it is at Crossness and Barking?—But the only fresh water coming into the Thames every day is the upland water; it is impossible for any water to come

*Mr. B. Latham, M. Inst. C.E.*

6 Feb. 1883.

in from the sea which is fresh, because the tide can only run up 12·6 miles, and it can only run down 12·6 miles, so that there is an interval between them of the distance of two tides in which no water fresh from the entrance of the river or fresh from the uplands can enter.

8419. If you take only the water over Teddington Weir and the other inflows, it represents a dilution far exceeding four to one, does it not?—No, not in a dry time.

8420. Pardon me; let me remind you that you have told us that 125,000 cubic feet represent the average fresh water and 20,000 cubic feet represent the sewage?—But there is another little calculation you must bear in mind, and that is this, that you only discharge the sewage upon half the water that is passing; that there is one section only of the water that it goes into.

8421. You mean the River Thames is like a chess-board with black and white squares, sewage squares and pure squares, that there are alternate lengths, which are pure water and sewage water?—That would be upon one tide, but the mixing action, of course, immediately disposes of all that. But the fact is, as I say, that while you are really discharging you are discharging only upon a certain portion of the water and not upon the whole volume going down.

Re-examined by Mr. Lumley Smith.

8422. I am not going to take you over the whole field of my learned friend's cross-examination, but I wish to ask you one or two questions. First of all, with regard to the floats you directed, and instructions, as I understand, were given in writing, what float experiments should be made?—Those directions were given in writing and they were approved by Sir Thomas Nelson before they went off.

8423. You personally did not follow any of the floats in a boat or anything of the kind, you had to trust to the persons who were under you?—Yes.

8424. I believe Mr. Birch supervised the observations more particularly than you did; to what extent did you personally take part in them?—I personally occasionally visited the locality while the experiments were going on, but Mr. Birch had the personal charge of the floats. He did not devote his whole attention to the float observations but he did other things as well. He personally assisted us with the gaugings and other matters also.

8425. Did you go down as often as once a day?—No, I only went down occasionally.

8426. For the actual watching of the floats you were, of course, depending upon the men who were with the floats?—Yes.

8427. Mr. Birch, as I understand, lived on board the "Toby" steam tug, and watched the floats?—Mr. Birch had other assistants with him to look after the floats, and from day to day they plotted upon a large scale diagram the course of the floats, and every week the large scale-diagrams were sent to me, and I worked out the observations upon them.

8428. Of course, for the actual watching of each particular float you were dependent upon the honesty and vigilance of the men who were watching the floats?—Certainly; if the men were tampered with or tempted to tie the floats up at night, we could not help a thing of that kind. We have done our best to make the experiments as fair as possible to all parties.

8429. Have you had any complaint made to you, or have there been made any complaints to the City authorities that there had been any neglect of duty?—No. I believe, before the experiments were really commenced, that is to say, before the 17th, a man was found to have tied his float up at night; that circumstance did arise, I know, but it was before the experiments were fairly begun.

8430. As far as you are able to judge from the actual results which have been furnished to you, do you find any difference between the night journeys and day journeys which would lead to any inference that there was a different course of proceeding by night from that by day?—No; I find the fact, which naturally at this period you expect, of a diurnal difference in the range of the tides; and where there is that diurnal difference, the up tides must naturally be the strongest. If you compare the experiments which have been put in by Mr. Phillips, you will find that the day tides are the strongest, and that their up tide at night is very much less than our up tide at night; but the up tide in the day is very much stronger, showing the same features with regard to the diurnal variation of the tides. I have coloured upon this diagram, which has been handed in before, the night tides and the day tides, and I find the average of all the nights is 12·92, and the average of all the days is 12·46, showing that the length of tide has been greater at night, and that there could have been no tying up, as otherwise there must have been a very much smaller run made than was made, and that therefore they corroborate each other in this respect.

8431. And even assuming there may have been some isolated instance of want of care, do you think that the float observations are fairly to be depended upon as accurately stating the effect of the journeys of the floats?—Yes, and especially if you look at the fact that if you deduct, the eight days I mentioned with regard to the D diagram, there remain only 4 per cent. of all the observations which are questioned by the Metropolitan Board.

8432. As regards the case of the float No. 8, distinct directions were given that it should be kept in the direct tidal stream?—Yes.

8433. Does the force of the stream vary very much in different parts of the river?—The float observations show what variation there is in the different parts.

8434. May I take it that the stream varies very much?—In the cross-section it varies immensely, because at the sides the force is very feeble. In the centre, where the tides are moved by the law that the velocity is in the proportion of the square root of half the depth of the stream, there the velocity is considerably greater.

8435. Then, further, I understand that there would be wind, there would be eddies, and there would be accidental influences, and so on, which would affect the motion of the various floats?—Yes.

8436. As far as the instructions to your men were concerned, I understand as long as the float was travelling they were not to interfere with it; if the wind blew it to the side they would leave it there?—If the wind blew it to the side, and it was travelling, they were to leave it there.

8437. And if it got into slack water, what then?—If the float got into slack water, and it was still floating down, then it would be left; it was only to be interfered with if it got foul of a ship, or got aground; it was to resemble a particle of sewage as much as possible.

8438. Did you find that floats which were at various parts of the river progressed differently?—Yes, that is so. If you start floats at different periods of the tide from the same spot, you find they take totally different directions.

8439. Have you found that floats, which were at the same moment in the same cross-section, would pass each other?—That is quite a common thing.

8440. That which was on one side of the river would go faster than the other?—Yes, the float which was in the strong flow of the tide would go faster than the other which was not in the same strength of flow.

8441. Did you find that one of the floats, which had turned one of the corners of the reaches of the river, became susceptible of a different influence?—

Yes, to that drifting action, especially in a very narrow portion of the river.

8442. Then, supposing two floats in the course of a tide to behave in such a way that one goes very near to the corner, and the other goes just round the corner; that would make a very considerable difference in the journey of the two floats?—Yes, that would be so, or it might be that there was a shoal, as there is just above the West India Docks, where the water is very much shallower, and most of the floats which have been pointed out as open to remark have been influenced by that shoal.

8443. Then with regard to the diagram which my learned friend, Mr. Bidder, put into your hand, showing that upon the same day different floats have behaved in a different manner; does that lead you to doubt the correctness of the float observations?—No, I should say that taking them on the whole they confirmed the result of the observations.

8444. You have put in a diagram to-day showing the journeys of each float in which each float is distinguished by a different colour?—It is.

8445. You have explained that each is distinguished by a firm line and by a dotted line?—The firm line refers in all cases to the top of the tide, and the dotted line refers to the bottom range of the tide of the same float, and the singular fact is found that the bottom range of one float often agrees with the top range of another float, because they happen to get in the same part of the river; that is the case in those very instances which have been mentioned by the Metropolitan Board of Works as being discordant, showing that the moment the floats get into the same part of the river and are subject to the same influence, they obey the same natural laws.

8446. Of course that diagram would show it in a minute, but do you find that the discords occur chiefly in a particular part of the river?—They do.

8447. Can you state generally in what part of the river it is that those discordant observations are occurring?—They occur in that part of the river from three miles to ten miles above the northern outfall, or in that twisted and irregular part; every one of the floats implicated has been in that twisted part of the river.

8448. Is that a part of the river where you would expect to find the floats subject to discordant influences?—It is just that part of the river where you would expect to find them subject to discordant influences.

8449. Why is that?—On account of the irregular nature of the channel you would expect to find cross currents, and there are the shoals which I have already mentioned, towards the upper part near the West India Docks, but Mr. More will be better able to give you an account of the physical features of this part of the river than I am.

8450. Now I want to go to a more important question, and that is this: It has been pointed out, and of course it appears upon the face of these diagrams that many of those floats at the end of their stage of probation had actually gone up the river instead of going down?—Yes, but I do not say "at the end of their probation;" they have at a certain period of their course gone up the river.

8451. And of course the observation is patent also that if these floats accurately represented the course of the main body of the water in the Thames, no water ever would have gone out of the River Thames at all?—That is so. There is probably an explanation for that, but that explanation I must say is not my own; it is due to Professor Unwin, whose valuable services we have had upon this matter. He pointed out to me that in all probability it was due to this fact, that in tidal water in going up the stream the water obeys the law of a tidal wave, but in coming down it flows off more generally as a flowing stream. The consequence is that the velocity of the tidal wave being very much greater in deep water the curve of velocity is sharper than it is in the case of the ordinary flow down, where it is flatter, the float in the middle of the river would have a greater tendency to go up upon the tidal wave than it would have to come down again upon the ordinary flow.

8452. Now I wish to ask you your view of the matter. Of course we know that during all the time that the floats were in the water every day a certain contribution came over Teddington Weir into the Thames?—Yes, but I may say that I think Professor Unwin's explanation is the correct one.

8453. (*Chairman.*) You adopt it?—I adopt his explanation.

8454. (*Mr. Lumley Smith.*) What I was going to ask you is whether you could tell the Commission in a compendious way how far these float experiments are a guide or can be treated as a fair standpoint of deduction with regard to the sewage getting out to sea. You have told us over and over again in answer to my learned friend's questions, when he was asking you whether the floats actually represented the voyages of the water that they showed the horizontal oscillation of the tides. I want to know your view as to the extent to which these floating experiments act as a guide to show us how soon the sewage would get out to sea?—With regard to the float experiments themselves, they have nothing to do with showing how soon the sewage gets out to sea; they simply show that where the floats have gone sewage could go as shown by the chlorine tests, for in no case could sea water have gone up the river without the sewage going up with it.

8455. I think my learned friend rather suggested that the sewage was not made of the calibre of these floats; there might be some difference between the movement of large particles and of small particles, I presume?—Yes, some of the sewage goes down at once to the bottom of the river as solid matter, and stops there in the bed of the river.

8456. Sewage matter as soon as it begins oscillating would keep oscillating with the tide backwards and forwards until it got out?—The sewage, or the remnants of sewage, would still keep oscillating backwards and forwards with the tide just as the floats did.

8457. Is there any possible mode of knowing how much is deposited of the solid matter; is there any engineering mode of arriving at it in any way, or is it a matter of observation? — The only mode of arriving at it is to look at the enormous quantity of 200,000 tons a year which is passed in from the sewers, and ask what becomes of that solid matter, and looking at the enormous amount of mud upon the banks the question is answered by the production of that enormous amount of mud.

8458. Now a word or two upon that question of the solid matter. In forming an idea of the amount of solid matter which actually goes into the Thames every year, what is it that you mainly rely upon?—I have relied upon the experiments made by the Metropolitan Board of Works themselves with a very large volume of sewage in the A.B.C. experiments.

8459. That you rely upon?—That I say showed at any rate this, that the solids must have been very much more because it is quite clear, in fact they confess that the sewage upon the south at that period was abnormally weak, and we know that the volume of sewage per head of the population on the south was very much greater than on the north, and that if it gives 57·4 grains per gallon upon the south it must give very much more upon the north, but taking it as we have it upon the south it shows that there is 200,000 tons a year of solid matter thrown into the Thames with the sewage.

8460. Now my learned friend, Mr. Bidder, tried to throw doubt upon your calculation by suggesting that you had done this, that you had not taken upon any particular day the amount of solid matter in effluent water and the amount of solid matter in sewage, but that you had taken the mean in your period of observation of these two amounts of solid matter. Now is not that what in fact is done by Mr. Keates in his report to the Metropolitan Board of Works?—

*Mr. B. Latham, M. Inst. C.E.*

6 Feb. 1883.

Mr. Keates has given the average of his effluent water, and I have taken his average.

8461. The principle of taking an average is adopted in that report?—Certainly it is, and it is adopted by everybody. He is supposed to have written this report with a view to inform us what really took place in these A.B.C. experiments, and he shows us that by taking a certain number of analyses of the sewage and a certain number of analyses of the effluent water, we are enabled to judge what the effects of the process have been, and by comparing those as I have done we come to the figure 57·4 grains of suspended matter to the gallon of sewage.

8462. And you depend upon the calculation you get from that experiment?—I say that if the figures in Mr. Keates' report are correct then my calculation is correct; if Mr. Keates' report is wrong, then my figure would be wrong.

8463. Then, looking at the matter in a different point of view, and corroborating that, if possible, you adopt the mode of taking the $3\frac{1}{2}$ ozs. per head?—I simply mentioned the $3\frac{1}{2}$ ozs. as agreeing so nearly with the total solids in sewage. I did not base any calculation upon them except that I was asked the question how much it would come to, and I gave it; but all my calculations are based upon the one fifth of a lb. per day, which is my own observation, or they are based upon the result of the A.B.C experiment of the Metropolitan Board of Works.

8464. Does the $3\frac{1}{2}$ ozs. represent the amount of dry matter which is produced per head of the population?—Dry matter of all kinds.

8465. That of course includes dry matter from the urine?—It includes dry matter from the urine, but you will find I went further and said that the other solids made up the amount of the $3\frac{1}{2}$ ozs. in place of that which was in solution.

8466. When the $3\frac{1}{2}$ ozs. gets into the Thames a portion of it would go into solution, that is to say, a portion of the original $3\frac{1}{2}$ ozs. of dry matter would go into solution; would there be anything to make up for that loss?—In my mind I had all the solids of other matters which would distinctly make up the same thing.

8467. What is it that goes up to make this loss?—The paper, to a very large extent; there is solid matter from kitchens, grease and things of that kind, which are separate from sewage.

8468. Are those what you meant in your answer to Question 7902, when you said "And of that a part "would be in solution, so it would not be fair to "assume that as all being in suspension, but there are "other matters in the fæcal matter which would take "the place of that matter in solution?"—Yes, exactly, those are the solid matters which are washed from the surfaces of yards and in cleaning floors, an enormous amount of that is carried down. A servant's pail after she has been scrubbing a floor contains an immense amount of solid matter which has been left there by the feet of people, and it all goes down the sewers. There is also, as I say, all the matter from yards and roofs, and streets, it is impossible to intercept the whole of it.

8469. And you take that as going to make up for the loss of the matter in solution?—This matter in suspension goes to make up for the loss of the matter in solution.

8470. Now a question about the vertical range of the tides. My learned friend, Mr. Bidder, drew your attention to page 38 of your report with regard to the length of the ebb and the flood at Teddington, you find that at Teddington the whole tide is said to be 12 hours 13 minutes, the flood being two hours three minutes, and the ebb being said to be 10 hours 10 minutes. I want you to explain the nature of the error, you said it was an error, but that it was an error which was unavoidable?—Yes, it was an error which was unavoidable, because they were scaled off the tidal diagram, and it is impossible in many of the tides to distinguish between flood and ebb. There is an error there of about 12 minutes, which should be added to these tables to make the range correct.

8471. Do you get the full flood and ebb in the 12 hours there?—The tidal period is about 12 hours and 25 minutes, and all the tides should conform to that figure, but when you come to scaling the diagram it is utterly impossible, unless you manipulate the figures in some way, to get it exactly.

8472. At Erith I notice it is put down as 12 hours and 25 minutes, and at two other places the same, whereas at Gravesend it is put down as 12 hours and 24 minutes. Gravesend is, I suppose, a minute wrong?—Yes, these times have been taken out from the diagrams.

8473. And from the nature of the instruments used it is absolutely impossible to get accurately at the time?—Yes, that is so, on account of the small scale of the diagram, for instance in the Gravesend experiment a tide would occupy only an inch and a half in length.

(*Sir John Coode.*) Considering the influence of the wind on the tide one is surprised to find that the figures come out so accurately as they do.

(*Witness.*) Perhaps I might explain another matter about the floats which might lean to some disagreement, when Mr. Bidder put a question about the range being nearer midnight or how I took it, he used the word "tides," which might lead to a misunderstanding. It simply means (as I have divided all these into up and down for morning and evening) that if the float were moving up the river, and the biggest part of the flow was before midnight, it would go as an afternoon tide, and if, on the other hand, the biggest part of the flow were in the morning, it would go as a morning tide. He asked me as to a tide at 3 o'clock in the morning; of course if a tide came to high water at 3 o'clock in the morning that part which went down after the time would be a morning down tide.

8474. My learned friend, Mr. Bidder, was asking you this to-day whether a difference might not be made in your figures if the amount of chlorine in sewage were taken at 20 instead of 10 parts in 100,000, you have taken it at 10 and they suggest it ought to be taken at 20?—Yes.

8475. Have you calculated at all the difference that would be made, assuming that figure to be correct, with regard to the lower reaches of the river?—It would make very little difference in the lower reaches.

8476. The amount of sewage in that water compared to the amount of sea water would be so small that it would be practically imperceptible?—I will have the result worked out and lay the result before you, but as I have stated, in the lower parts it would make very little difference indeed.

8477. Where did you get your amount of 10 parts in the sewage from?—That figure of 10 parts is the figure our chemist will give you as the standard of average sewage, if you took a very strong sewage it might be 20, but taking it on the average, I understand it to be 10.

8478. Have you ever seen it suggested in any of the Reports of the Metropolitan Board of Works that the Thames water was used for flushing the sewers?—Never.

8479. I believe we have had figures given us showing the amount of sewage pumped at Crossness?—Yes.

8480. I believe Sir Joseph Bazalgette has given them to us, and they are published every year?—Yes; but in reference to your previous question, I ought to say that many of the sewers are at such a level that it is utterly impossible to get water into them from the Thames to flush them.

8481. But, as far as the figures are given, relating to Crossness, they give the number of gallons pumped out at the outfalls?—Yes.

8482. They give the amount of sewage and not of the water used for flushing?—Yes; but the important question is, why you should have this enormous difference always upon the south as against the north; you find there is nearly twice as much, proportionally, of

sewage year by year upon the south as there is upon the north. Now, surely, if the sewers require flushing upon the south, those upon the north also require flushing.

8483. They have storm overflows upon the south, have they not?—They have a very large number of storm overflows all the way down the river.

8484. Now, a question with regard to the way in which you have calculated the proportion of chlorine in the combination of river water and sewage. It is necessary, as you have told us, to make an assumption of the quantity of each which is in the mixture; you know what is absolutely the amount of chlorine in the sea, and by mixing water and sewage you can tell the quantity in the mixture?—We know absolutely the quantity of chlorine in the river water, as that is taken, and we know absolutely the quantity of chlorine in sea water, because that is a well ascertained fact. The chemists determine for us the amount of chlorine in the mixture, and there can be no doubt about that.

8485. The amount of chlorine in the mixture is arrived at by taking on a particular day the amount of water coming over Teddington Weir the amount of sewage coming out of the outfalls?—Yes.

8486. My learned friend, Mr. Bidder, suggests that you will not find the exact quantity of water which goes over Teddington Weir upon any particular day of the week mixed with the given quantity of water, which comes out of the sewers upon that same particular day, because the water will not come down from Teddington to the outfall in one day, and that is the fact, because the Teddington water will take some days to get down, and it varies every day, no doubt, in quantity; but taking the quantities upon a particular day is that a fair way to do it?—Yes; I have already explained that if you put a given quantity of water into the river at Teddington it immediately displaces a like quantity of water further down the river; the tidal impulse only takes one hour and twenty minutes to travel from London Bridge to Teddington, and exactly the same kind of impulse is transmitted by the water entering the channel at Teddington, but, although, it may not be the particular particle of water which came in at Teddington, yet it pushes an equal amount forward further down.

8487. Would the difference between one day and another, taking an ordinary average flow at Teddington, make any difference practically in the mixture as regards its being a fair average mixture?—Of course, if you could suddenly jump from extreme low water to extreme flood water, it would make a difference in the proportions of the mixture, but it would not make a difference in principle, as you would have an equal quantity of water pushed out to that which you had coming in. You may imagine really a long trough filled with clear water, if you pour in a pint of ink at the upper end, a pint of ink will not run out at the lower end; a pint of clear water will run out, but the impulse has been transmitted, which causes the clear water to run out.

8488. At any rate would the difference be effective in any way compared with the vast body of sea water in the lower reaches to disturb the calculations?—No. You will see from the calculation I put in (showing the absolute correctness of the tables I have put in) that, taking the relative volume of tidal water at Southend and upper river water, and taking sea water with a mixture of river and sewage water whether in the lower reaches or the higher parts of the river, there is practically no difference.

8489. I would not ask you any more questions upon that, because I find my learned friend, Mr. Bidder, at question 7548 said "In the lower reaches, where the proportion of chlorine reaches hundreds of grains, the relative proportions of fresh water and fresh "water and sewage are not important." That is so, is it not?—It is.

8490. You were asked a question which involved two hypotheses, one of which was, assuming that the sewers were made for the then population, with the margin of taking double their average flow; then the next hypothesis was, supposing the maximum flow was only 40 per cent. above the average, would the sewers then be competent to take the sewage of the population?—I have already shown that the whole of the calculations which I have put in have been based upon the figures given by the Metropolitan Board of Works.

8491. Have they anything to show that the sewers are ample for the population?—The very figures that I have taken, their own figures, show that the northern outfall never was big enough for the population.

8492. Now you were asked a question about the rainfall. My learned friend suggested that those were new observations which were invented for the purpose of this inquiry. Now, those are in your book, are they not?—Yes, I think it is desirable that you should have some information as to the operation of the rainfall in the London sewers.

Mr. Norman Bazalgette objected to the introduction of this, as being new matter.

The Chairman ruled that the evidence was admissible.

(*Witness.*) This is what I have already written with regard to the London sewers, beginning at page 52 of my work on Sanitary Engineering:—"Although "the sewers of London are calculated to carry away "rain at the rate of a quarter of an inch in 24 hours, "and it is stated in Sir J. Bazalgette's paper on the "'Main Drainage of London,' that there are not "more than 25 days per annum when the rainfall "in 24 hours exceeds this quantity, it must be "apparent that the sewers of London are only cal-"culated to convey away one-hundredth of an inch "of rainfall and subsoil water per hour, in addition to "the sewage, and whenever the rainfall exceeds this "rate of fall, although the total fall in twenty-four "hours may not equal a quarter of an inch, great "inconvenience must naturally be occasioned in the "low level districts, especially if the rain occurs at "periods when the sewers are tide-locked, and cannot "consequently get relief by the storm water overflows. "Experience in connexion with the metropolitan "sewers has shown that the allowance made for rainfall "and subsoil water in the low-level districts is not "sufficient, and consequently some of the low-lying dis-"tricts which are below high-water mark get flooded, "the reason being that, in the low-level districts, "when there is a rainfall exceeding the quantity the "sewers are constructed to contain, and at the same "time the storm-water outlets are tide-locked, the "low-lying districts cannot get relief, and are con-"sequently flooded. To obviate this inconvenience, "the Metropolitan Board of Works have determined "that, when the low-level sewers are filled to excess, "and no relief can be afforded by the storm-water "outlets by reason of the state of the tide, the ex-"cess, or what would, under similar circumstances in "a high-level sewer, flow direct to the Thames, "shall, in case of the low-level sewers, be pumped "into the river. From the discussion which took "place at the Institution of Civil Engineers, after "papers had been read on the drainage of London "and Paris, it appears that in 1857 Messrs. Bidder "and Hawksley found in the case of London, that "with a rainfall of 2·90″ in 26 hours, Savoy Street "sewer delivered 64·5 per cent., Ratcliffe Highway "sewer 52 per cent, while Lieut.-Colonel Haywood "found in the same storm that London Bridge sewer "discharged 53 per cent. Lieut.-Colonel Haywood, "in April 1858, had gaugings taken of the same "sewer, 'when ·24 of an inch of rain fell in an "'hour and a half; he then found that 74 per cent. "'of the total quantity ran off, leaving 26 per cent. "'to be absorbed or evaporated. Of a rainstorm "'of ·54 of an inch, in five hours in June 1858, "'there was delivered into the Irongate sewer, which "'drained an area entirely paved and built over, as "'much as 94·5 per cent. of the total rainfall; and "'of all the storm gaugings he had made, that was "'the greatest per-centage he ever knew discharged

*Mr. B. Latham, M. Inst. C.E.*

6 Feb. 1883.

" 'by a sewer. In August 1858, with a rainfall of " '·48 inch in one hour and two-thirds of an hour, " 'he found only 78 per cent. of the total quantity " 'discharged into the Irongate sewer.'"

8493. (*Mr. Norman Bazalgette.*) Will you read on to the words "one tenth of it to the sewers"?—"The "author has found that the amount of water con- "tributed in various districts depends very much "upon the character of the surface which receives "the rainfall. In districts in which the geological "character is porous, the rain contributed to the "sewers is very small. For example, in the case of "Croydon, where the geological formation principally "consists of gravel overlying chalk, the amount of "rain contributed by a storm of ·72 of an inch in "12 hours in October 1865 did not yield more than "one-tenth of it to the sewers." That only shows that in the case of Croydon these rains affect the sewers to nothing like the extent they do in London; yet in Croydon I have shown that a normal rainfall has produced a fluctuation in the sewers which is vastly more than anything the London sewers can deal with.

8494. (*Mr. Lumley Smith.*) Have you anything to say with regard to the chalk wells?—The wells further inland than Grays show that they have not that same amount of chlorine in them, and samples of water taken the same day show that they are not influenced in the same way. Near Erith the distant wells yield 1·4 in 100,000 of chlorine, showing that that is the standard amount of chlorine in the inland districts, and that it is only when they come within the range of the tide that there is shown to be an increased amount of chlorine directly due to the effect of the tidal water.

8495. (*Sir John Coode.*) You have given the Commission some figures with regard to the increased range of the tide of late years, and you stated that you considered that that increased range was due to the improved sectional area of the channel by dredging operations. I thought you gave that with some hesitation. Is that based upon any information and figures as to the amount of improvement and deepening in the channel?—I know there is an improvement in the river. I have seen the figures of the enormous dredging which has taken place of late years.

8496. But it is all assumption, is it, or have you made any comparison as to the increase of range corresponding with the increase of the dredging?—Yes, I have. I am able to show that there is now an increased velocity up the river. The range in 1858, that is to say, the average speed of the wave travelling up, from the Nore to London Bridge, was one hour and 40 minutes, whereas now it is one hour and 30 minutes.

8497. In making your observations had you any tide gauges?—We had recording tide gauges at Deptford, Erith, Gravesend, and Southend, and we read them every day.

(*Sir John Coode to Mr. Lumley Smith.*) I cannot help thinking that if you have observations on tide gauges made at different parts of the river, a diagram plotted showing the surface of the river, and the water gradients at high, low, and half tide, both flood and ebb, would throw some considerable light upon these apparent eccentricities which have been remarked upon.

(*Mr. Lumley Smith.*) We have had one prepared I think at high tide, and at low tide. I do not know whether that will answer your purpose.

(*Sir John Coode.*) We want it done at a considerably distorted scale, at say four miles to an inch, and an eighth of an inch to a foot vertical; if you could give us the high and the low water surfaces at high water, low water, and half water, flood, and ebb, that would throw considerable light upon the subject of the supposed discrepancies and discordancies. I mean in a longitudinal section.

(*Mr. Lumley Smith.*) We will endeavour to have it done.

8498. (*Colonel Ewart to the Witness.*) You have referred in your evidence to the storm outlets and overflows; have you taken any specimens of the discharges of them?—I have seen them discharging, but have not taken any samples.

8499. You have not had any specimens analysed?—I believe they have been analysed, but I am by no means certain. I have seen the one at Blackfriars Bridge, the one at the end of the Fleet, and it always strikes me that what is discharged by it is much more filthy and much more concentrated sewage than that discharged from the main outfalls, and they are now making other overflows the effect of which will be to bring the rainfall and sewage combined to a greater extent into the upper parts of the river.

8500. In the course of these investigations have you been much upon the river yourself?—Yes.

8501. With regard to your table on page 18 of the Minutes of the Sixteenth Day, I see that you calculate what will be the probable increase of population up to the year 1901; in the north it amounts to an increase of about one fourth, and in the south, I think, to an increase of more than half; but inasmuch as the metropolitan areas upon the north and south are not elastic, must not that be dependent upon whether or not there is room to build?—Of course the tendency under those circumstances is to aggregate a greater number of persons in a house; it is shewn that there is a greater number of persons in a house upon the north than there is upon the south. The proportion is eight persons to a house in the north and seven in the south.

The witness withdrew.

Adjourned to to-morrow at half-past 12 o'clock.

# TWENTIETH DAY.

## Wednesday, 7th February 1883.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.

FRANCOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.

WILLIAM POLE, ESQ., F.R.S., *Secretary.*

Mr. JAMES MANSERGH, Mem. Inst. C.E., F.G.S., F.M.S., examined.

*Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.*

7 Feb. 1883.

8502. (*Mr. Balfour Browne.*) You are a member of the Institution of Civil Engineers, and of various other societies, and have been in practice as a civil engineer for a good number of years?—Yes, I have for 25 or 30 years.

8503. I think your practice has been almost exclusively in designing and carrying out works for the disposal of sewage and for water supply?—Yes.

8504. During that long period you have reported and advised upon a very large number of water supply works and sewage works?—For about 200.

8505. Both for corporations and other public bodies at home and abroad?—Yes.

8506. How many works may you have carried out?—In about 60 different towns.

8507. In order to give the Commission an idea of the extent to which you have been engaged, would you mention some of the towns with which you have been connected?—Bedford, Grantham, Tunbridge Wells, Reading, Southport, Middlesbrough, Lincoln, St. Albans, Burton-upon-Trent, &c.

(*Chairman.*) We will take all those for granted.

8508. (*Mr. Balfour Browne.*) In many of the cases which you have just been mentioning has the disposal of sewage been the object which you have been called in to advise about?—Yes, I have been called in to drain the towns, and to dispose of the sewage.

8509. Have you been connected with works for the disposal of sewage by precipitation in tanks, irrigation of and filtration through land, and its discharge into tidal rivers and estuaries?—Yes.

8510. I think you were one of a number of engineers who prepared schemes for the Lower Thames Valley Drainage?—Yes.

8511. And you received one of the three premiums awarded for that matter?—Yes.

8512. And you were engaged before the Commissioners in the Inquiry of 1879–80 as to how to dispose of the sewage of the Lower Thames Valley?—Yes.

8513. And you have acted as an arbitrator with reference to the pollution of the River Tees?—Yes; there was a question in the year 1878 as to the pollution of the River Tees by the discharge of the sewage of Middlesbrough into it, and I was one of the arbitrators engaged in that case.

8514. I believe you gave evidence on the long inquiry into the mud in the Thames?—I did. I was one of the witnesses for the Conservators upon that inquiry.

8515. In the course of that inquiry you had opportunities of becoming acquainted with the Thames?—I had. I went down the Thames a good many times, and got up a lot of information upon the subject, and became very well acquainted with the whole state of the case.

8516. Especially, I think, in connexion with the outfalls at Barking and Crossness?—Yes, that was so.

8517. For the preparation of this case have you been associated with Mr. Baldwin Latham and the other witnesses in getting up the facts which are to be laid before the Commission?—I have.

8518. And you are acquainted with the data which have been collected for the purpose of throwing light upon this matter?—I am.

8519. And I think that, in conjunction with Mr. More, you have prepared a longitudinal sections of the Thames, from Teddington to Southend?—Yes.

(*The same were handed in. See Appendices W. 1 to 4.*)

8520. Will you just tell the Commission how many cross sections you made of the river for the purpose of making that longitudinal section?—Between Teddington and Southend I have made 133 cross sections between something above high water and something below low water. The surveys of the Thames Conservators are below low water, that is to say, their soundings are all taken below low water, and in order to get cross sections of the river up to high water those sections were taken.

8521. Then by the use of these cross sections, and also by information supplied by Mr. More from the surveys of the Thames Conservancy, have you got at the cubic capacity of the river, and is that shown upon those sections?—It is for four tides—there are two spring tides and two neap tides, and of the two tides, one of each had a small quantity of land water in, and the other had a large quantity of land water in.

8522. I see there is a table handed in with those cross sections which explains them?—Which gives the capacity.

(*The following Table was handed in. See page* 282.)

8523. There are four longitudinal sections?—Yes.

8524. Marked A, $A^1$, B, $B^1$?—Yes.

8525. Will you take the first two of those, A1, and A?—The first two of those were spring tides, A1, being that of the 1st of October 1882, the height of which by Roberts's Tide Table was 29 feet 2 inches on the sill of the Shadwell lower entrance of the London Docks.

8526. I see that on one of those occasions there was a flood in the river?—Yes.

8527. And the other was about the ordinary amount of tide?—Upon the 1st of October tide there was 179,000 cube feet per minute running into the Thames from Teddington and the tributaries below to Southend—on the other spring tide, that on the 30th and 31st of October, there was running in 1,303,924 cube feet—about from six to seven times as much.

8528. Those figures appear upon the table of reference?—They do.

8529. The third tide, B, I see was a neap tide upon the 6th of October, 1882?—That was so.

8530. What was the height?—The height upon the tide table was 24 feet 6, and the quantity of land water coming in between Teddington and Southend, including Teddington, was 143,220 cube feet per minute. Then on tide $B^1$, which was also a neap tide, of the 4th of November, there were 24 feet 8 inches on Roberts's tide table, but on that occasion 708,694 cube feet of land water a minute were coming into the Thames.

*Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.*

7 Feb. 1883.

TABLE of CAPACITY of RIVER THAMES as shown on LONGITUDINAL SECTIONS marked respectively A¹, A, B, B¹.

N.B.—On these sections the line dividing the light and dark blue colours represents the surface of the water from Teddington to Southend, *at the time of low water at Southend* for each of the tides, and the upper line bounding the dark blue represents the surface of the water from Teddington to Southend *at the time of the following high water* at Southend.

The dark blue colour shows therefore the quantity of water which entered the river both from the Thames above Teddington and the tributaries between Teddington and Southend, and from the sea, during the time of flood tide at Southend, and is called "tidal water" in the table;—the light blue colour is called "low-water content."

| | Low-water Content. Light Blue. | Tidal-water, including inland and sea-water, entering during flood tide. Dark Blue. | Total Content of River. Teddington Southend. |
|---|---|---|---|
| | Cube feet. | Cube feet. | Cube feet. |
| TIDE A¹.—Spring tide of 1st October, 1882 (29 ft. 2 in. on Roberts' Tide Table), with relatively small quantity of land water coming in, viz.:—179,099 cube feet per minute from Thames above Teddington and tributaries below. Time of Low Water at Southend - - - - - - 9.25 a.m. Do. High Water do. - - - - - 3.8 p.m. Duration of flood tide at Southend - - - - - 343 minutes. | | | |
| Low-water Content between Teddington and Barking - - - - - | 1,337,062,090 | | |
| Do. do. between Barking and Southend - - - - - | 17,736,971,361 | | |
| Tidal Content between Teddington and Barking - - - - - | | 1,720,178,285 | |
| Do. between Barking and Southend - - - - - | | 18,576,054,395 | |
| Total Low-water Content between Teddington and Southend - - | 19,074,033,451 | | |
| *Total Tidal Content between do. do. - - - - | | 20,296,232,680 | |
| Total Content of River—Teddington to Southend - - - - - | | | 39,370,266,131 |
| *N.B.—Of the 20,296,232,680—61,400,087 cube feet are land water, and 20,234,832,593 cube feet are from the sea. | | | |
| TIDE A.—Spring tide of 30th–31st October, 1882 (28 feet 2 in. on Roberts' Tide Table), with relatively large quantity of land water coming in, viz.:—1,303,924 cube feet per minute from Thames above Teddington and tributaries below. Time of Low Water at Southend - - - - 9.20 p.m., Oct. 30th. Do. High Water do. - - - - 3.15 a.m., Oct. 31st. Duration of flood tide at Southend - - - 355 minutes. | | | |
| Low-water Content between Teddington and Barking - - - - - | 1,547,279,429 | | |
| Do. do. between Barking and Southend - - - - - | 17,433,521,276 | | |
| Tidal Content between Teddington and Barking - - - - - | | 1,693,050,308 | |
| Do. between Barking and Southend - - - - - | | 18,905,450,703 | |
| Total Low-water Content between Teddington and Southend - - - - | 18,980,800,705 | | |
| *Total Tidal Content between do. do. - - - - | | 20,598,501,011 | |
| Total Content of River—Teddington to Southend - - - - - | | | 39,579,301,716 |
| * N.B.—Of the 20,598,501,011—462,893,020 cube feet are land water, and 20,135,607,991 cube feet are from the sea. | | | |
| TIDE B.—Neap tide of 6th October, 1882 (24 ft. 6 in. on Roberts' Tide Table), with relatively small quantity of land water coming in, viz.:—143,220 cube feet per minute from Thames above Teddington, and tributaries below. Time of Low Water at Southend - - - - - - 1.7 a.m. Do. High Water do. - - - - - 7.37 a.m. Duration of flood tide at Southend - - - - - 390 minutes. | | | |
| Low-water Content between Teddington and Barking - - - - - | 1,603,666,012 | | |
| Do. do. between Barking and Southend - - - - - | 21,551,899,564 | | |
| Tidal Content between Teddington and Barking - - - - - | | 1,025,235,800 | |
| Do. between Barking and Southend - - - - - | | 9,888,777,284 | |
| Total Low-water Content between Teddington and Southend - - - - | 23,155,565,576 | | |
| *Total Tidal Content between do. do. - - - - | | 10,914,013,084 | |
| Total Content of River—Teddington to Southend - - - - - | | | 34,069,578,660 |
| *N.B.—Of the 10,914,013,084—55,855,800 cube feet are land water, and 10,858,157,284 cube feet are from the sea. | | | |
| TIDE B¹.—Neap tide of 4th November, 1882 (24 ft. 8 in. on Roberts' Tide Table), with relatively large quantity of land water coming in, viz.:—708,694 cube feet per minute from Thames above Teddington, and tributaries below. Time of Low Water at Southend - - - - - - 1.0 a.m. Do. High Water do. - - - - - 7.10 a.m. Duration of flood tide at Southend - - - - - 370 minutes. | | | |
| Low-water Content between Teddington and Barking - - - - - | 1,457,944,341 | | |
| Do. do. between Barking and Southend - - - - - | 19,539,139,333 | | |
| Tidal Content between Teddington and Barking - - - - - | | 1,020,497,637 | |
| Do. between Barking and Southend - - - - - | | 9,476,250,993 | |
| Total Low-water Content between Teddington and Southend - - - - | 20,997,083,674 | | |
| *Total Tidal Content between do. do. - - - - | | 10,496,748,630 | |
| Total Content of River—Teddington to Southend - - - - - | | | 31,493,832,304 |
| *N.B.—Of the 10,496,748,630—262,216,780 cube feet are land water, and 10,234,531,850 cube feet are from the sea. | | | |

WESTMINSTER,
January 15th, 1883.

8531. How much was that over the mean—nearly six times the mean, I think?—Yes, about that.

8532. Now as I understand you have just described in words what those sections show graphically to some extent?—To some extent. I have not described what the lines mean.

8533. There are two colours upon this chart or section, the one dark blue and the other light blue?—Yes.

8534. What is the meaning of the line dividing those two colours?—The line dividing the light blue from the dark blue is the line showing the surface of the water from Southend to Teddington at the moment of low water at Southend; you may call that a synchronous line. Taking the exact time of low water at Southend, we have obtained from the six recording gauges the height at the site of those gauges at the same instant, and that line represents the surface of the water. Similarly the upper border of the dark blue shows a synchronous line of high water at Southend.

8535. So that taking the lower and the higher, does the boundary of the dark blue show the capacity between the two tides?—That shows the quantity of water which has entered the river between low water at Southend and high water of the succeeding tide; of course that includes the water coming in from the sea and the water coming in from the land.

8536. What is represented by the light blue colour?—The light blue colour represents the water in the river at Southend, at the time of low water at Southend.

8537. The dark blue, you say, represents the amount of water which has entered between low water at Southend and the next high water at Southend: from what sources has that water entered the river?—From the sea and from the land, from the Thames over Teddington Weir, and from all the tributaries between Teddington and Southend, and from the sea.

8538. And I may say, although I have only this one before me just now, that the same is done with relation to the whole four longitudinal sections?—That is so.

8539. In tide $A^1$, the tide being spring with a little land water, because the land water was only 179,000 cube feet, the quantity of water in the river below the low water synchronous line (that is the light blue) from Teddington to Barking outfall was what?—The low-water content between Teddington and Barking upon the A1 tide, light blue, was 1,337,062,090, cube feet. The low-water content between Barking and Southend was 17,736,971,361 cube feet.

8540. Then those two figures together represent the light blue upon the longitudinal section?—Yes, that is the whole of the low-water content at that time between Teddington and Southend. You will see it added up at the bottom—the whole low-water content was 19,074,000,000 cubic feet.

8541. Now just tell us the same figures, referring to the dark blue—what comes into the river from the three sources you have described, land water, Teddington Weir, and tributaries between Teddington and the sea?—The content of the dark blue, that is water coming in at flood tide between Teddington and Barking, was 1,720,000,000 cube feet (I need not trouble you with the small figures) and between Barking and Southend it was 18,576,000,000 cube feet.

8542. Making a total of how much?—Making a total of 20,296,000,000. Then the grand total of the whole—the whole content of the river between Teddington and Southend, at high water at Southend, was 39,370,000,000.

(*Sir John Coode.*) For all practical purposes it is about half and half—that is near enough for our purposes.

8543. (*Mr. Balfour Browne.*) Of that 20,296,000,000, how many cube feet of fresh water would represent the water coming over Teddington Weir?—61,400,000.

8544. Where does that appear upon the table?—It appears just at the bottom of the tables—it is marked "N.B."

8545. Does that 61,000,000 cubic feet represent not only the Teddington Weir water but all the land water?—The Thames coming over Teddington Weir, the River Lea, and the Cray, and all the tributaries between Teddington and Southend.

8546. Then the whole content of the river you have given?—Yes, that is 39,370,000,000.

8547. Now will you turn to the longitudinal section A, please. Section A was the one where the greater quantity of land water was coming in?—The A tide is the 30th and 31st of October tide.

8548. As we dealt last time with the light blue, first, perhaps we had better adopt the same course again. What was the amount of water between Teddington and Barking at low water?—The low-water content between Teddington and Barking was 1,547,000,000 cube feet.

8549. And from Barking to Southend?—From Barking to Southend it was 17,433,000,000 cube feet; the total low-water content was 18,980,000,000 cube feet.

8550. Again, as we have dealt with the whole of the light blue upon this section, would you just deal with the figures of the dark blue?—Now going to the tidal content between Teddington and Barking, it was 1,693,000,000 cube feet; between Barking and Southend it was 18,905,000,000 cube feet; the total being 20,598,000,000 cube feet. Of that 462,893,000 cube feet were land water.

8551. Just before we leave $A^1$ and A, there seems to be very little difference between the total content of the river upon those occasions?—A very little difference indeed. The total content of the river was 39,579,000,000 cube feet; only about 200,000,000 more than the tide in which the water was so very much less.

(*Mr. Michael.*) Practically, we may say it is one to one.

8552. (*Mr. Balfour Browne.*) Now the B tide instead of being a spring was a neap?—The B tide was a neap, the tide of the 6th of October.

8553. And there was upon that occasion comparatively little land water coming in?—143,000 cube feet per minute came in over Teddington Weir and from the tributaries.

8554. I want the same quantity above the synchronous line between the light and dark blue?—The low-water content between Teddington and Barking is 1,603,000,000 cube feet, and the low-water content between Barking and Southend is 21,551,000 000 cube feet, the total of the low-water content being 23,155,000,000 cube feet.

8555. Comparing that with the spring tide, the content is greater at low-water neap than it is at the spring tide?—Yes, the tide does not ebb out so far.

8556. Now with regard to the other figures, what comes in with the tide?—Between Teddington and Barking the tidal content is 1,025,000,000 cube feet, and between Barking and Southend it is 9,888,000,000 cubic feet.

8557. What is the total?—The total tidal content is 10,914,000,000 cube feet.

8558. What is the gross total of those two?—34,069,000,000 cube feet, and of the water coming in during the flood-tide 55,855,000 cube feet were land water.

8559. The amount of tidal water coming into the river on the neap tide seems to be a little more than half of what comes in upon the spring?—Yes, a little more than half of what comes in upon the spring.

8560. Will you just go over the same figures with regard to $B^1$ tide?—$B^1$ tide was the tide of the 4th of November when there were 708,694 cube feet of land water coming in between Teddington and Southend.

8561. I see that in all these cases you give the times of the tide?—The figures I have given below in the footnote are simply the figures I have given

*Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.*

7 Feb. 1883.

above multiplied by the number of minutes of the flood-tide at Southend.

8562. Now will you give the low-water content between Teddington and Barking upon this occasion?—1,458,000,000 cube feet.

8563. And between Barking and Southend?—Between Barking and Southend it was 19,539,000,000 cube feet, making a total of 20,997,000,000. The tidal content between Teddington and Barking was 1,020,000,000, and between Barking and Southend it was 9,476,000,000, making a total of 10,496,000,000, the gross total content of the river being 31,493,000,000. Of the tidal water the dark blue, 262,216,000 came in from the land.

8564. We have already pointed out that there is but little difference between the grand totals in the case of the two spring tides, but it does appear that there is a considerable difference in the case of the two neap tides—what is the difference?—There was one-twelfth more water in the river at high water upon the 6th of October than upon the 4th of November, although upon the 4th of November there was $5\frac{1}{2}$ times as much land-water coming in.

8565. I see that upon the 4th of November, which is the smallest tide, there were 708,000 cubic feet of land water going in as against 143,000 cubic feet of land water going in upon the 6th of October?—Yes, per minute.

8566. With regard to those two tides B and $B^1$, from looking at the tide table, what would you have expected them to vary in height?—The tide table said two inches.

8567. (*Mr. Michael.*) There is five times as much relative quantity of land water coming over in tide $B^1$ as in tide B, and yet the total quantity calculated at high water of the B tide is more than on the 4th of November, the B1 tide?—That I am going to explain now. Now this anomaly is accounted for from the fact that on or before the 6th of October the wind had been blowing for some time from the quarter between east and north, which would tend to keep both the high water and low water up; whereas on and before the 4th of November the wind blew somewhat strongly from the quarter between south and west, which would have the contrary effect. If you look at the diagram giving the force of the wind and the directions of the wind you will see that that is the cause.

8568. (*Mr. Balfour Browne.*) The diagram giving the force of the wind is already upon the tables put in by Mr. Baldwin Latham?—Yes.

8569. The fact is that upon one day, the 4th of November, there were five times as much water coming in from the river from inland sources as on the 6th of October, but the total amount was one-twelfth more on the 6th of October than it was upon the 4th of November, is that so?—That is so.

8570. Your explanation of that seeming anomaly is that the wind in the one case was favourable and in the other adverse?—That is so.

8571. Those sections that we have just been speaking of show that the water impelled into the river from the sea upon a high spring tide is twice as much, roughly speaking, as on a low neap?—Yes; you see that by the figures; in the one case it is about 20,000 million cube feet and in the other about 10,000 million cube feet.

8572. Do they indicate anything to your mind with regard to the effect of a large quantity of land water coming down the river?—Yes; that tends to raise low water from Teddington to London Bridge, and a little below, but it does not affect anything much beyond that point. It is the tidal wave which fixes the height of the tide, modified as I have stated by the wind.

8573. You have handed in this table which the Commissioners have before them to give all those figures in case they have not taken them down?—Yes; I have marked that table M1, that is the Capacity Table.

8574. Do you also produce a longitudinal section of the river from Teddington to Southend which shows the mean line between absolute high water and low water heights?—Yes; I have put on the section a mean line which has been deduced from a number of observations of the self recording gauges at Southend, Gravesend, Erith, Deptford Cattle Market, Chelsea, and Teddington.

8575. How long do those observations extend over?—The number of tides at Southend was, high water, 127, and low water, 126; at Gravesend, high water, 125, low water, 133; Erith, high water, 148, and low water, 148; Deptford, high water, 137, low water, 137; for Chelsea I have not the numbers; Teddington, high water, 141, and low water, 142.

8576. My learned friend, Mr. Bidder, wants to know before we leave table M1, whether the heights upon Roberts's tide table are the observed heights or the calculated heights?—They are the calculated heights as given upon the table.

8577. (*Mr. Bidder.*) You have not given us the heights which were observed upon those occasions?—I have not given you them, but I have given you the content, and the figure is given upon the table.

8578. (*Mr. Balfour Browne.*) You are going to give the heights now, I believe. In the section you have handed in there is a line shown in black, is there not?—There is.

8579. And that shows the mean you have just described?—Yes.

8580. What was the height of that line at the various points, beginning at Southend?—The mean between high and low water, obtained from the large number of observations which I have given, was at Southend O.D. + 1·89 feet, at Gravesend + 1·94 feet, at Erith + 1·96 feet, at Deptford Cattle Market + 1·98 feet, at Chelsea + 4·00 feet, at Teddington + 11·00 feet.

8581. And upon that section are the sectional areas of the river below the mean line shown?—They are shown, and they are also given upon Table M2.

(*The following was handed in.*)

RIVER THAMES.

*Mr. J. Mansergh, F.G.S., F.M.S.*

7 Feb. 1883.

SECTIONAL AREAS.

| No. of Cross Section. | Place. | Sectional Areas at Mean Tide, Levels. | Sectional Areas on 14th September 1882. | | Sectional Areas on 22nd September 1882. | | Sectional Area on 30th November 1882. | |
|---|---|---|---|---|---|---|---|---|
| | | | High Water. | Low Water. | High Water. | Low Water. | High Water. | Low Water. |
| | | Sq. ft. | Sq. ft. | Sq. ft. | Sq. ft. | Sq. ft. | Sq. ft. | Sq. ft. |
| 1 | Teddington | 1,601 | 2,518 | 806 | 1,624 | 977 | 2,489 | 1,877 |
| | | O. D.+11·00 | O. D.+14·90 | O. D.+ 7·30 | O. D.+11·10 | O. D.+ 8·10 | O. D.+14·70 | O. D.+12·20 |
| 27 | Chiswick | 5,102 | 9,500 | 2,818 | 7,082 | 2,974 | 9,035 | 3,825 |
| 45 | Chelsea | — | — | — | — | — | — | — |
| Between | | O. D.+ 4·00 | — | — | — | — | — | — |
| 55, 56 | St. Paul's Pier | 12,358 | 21,758 | 6,643 | 17,744 | 8,146 | 20,602 | 7,410 |
| Between | | | | | | | | |
| 66, 67 | Deptford | 22,280 | 34,501 | 12,927 | 29,453 | 15,031 | 32,791 | 12,900 |
| | | O. D.+ 1·98 | | | | | | |
| 4 | | 25,969 | O. D.+12·70 | O. D.− 7·50 | O. D.+ 8·30 | O. D.− 5·00 | O. D.+11·20 | O. D.− 7·40 |
| Between | | | | | | | | |
| 79, 80 | N. Woolwich | 31,257 | 46,229 | 18,731 | 40,405 | 22,324 | 44,258 | 18,817 |
| 83 | Barking | 43,993 | 65,791 | 27,094 | 57,409 | 31,899 | 62,983 | 27,219 |
| 88 | Crossness | 50,200 | 75,130 | 30,337 | 65,581 | 36,892 | 72,346 | 31,590 |
| 92 | Erith | 70,475 | — | — | — | — | — | — |
| Between | | | | | | | | |
| 93, 94 | Erith Pier | 69,558 | 96,835 | 47,142 | 87,085 | 54,812 | 93,293 | 47,908 |
| | | O. D.+ 1·96 | O. D.+12·10 | O. D.− 6·90 | O. D.+ 8·50 | O. D.− 3·80 | O. D.+10·80 | O. D.− 6·70 |
| 97 | Purfleet | 62,503 | — | — | — | — | — | — |
| 99 | | 65,903 | — | — | — | — | — | — |
| 113 | Gravesend | 96,674 | — | — | — | — | — | — |
| | | O. D.+ 1·94 | O. D.+11·30 | O. D.− 6·90 | O. D.+ 7·60 | O. D.− 3·70 | O. D.+ 9·50 | O. D.− 6·70 |
| 115 | Do. Ship and Lobster | 110,299 | 144,323 | 79,801 | 130,816 | 90,503 | 137,666 | 80,578 |
| 124 | Hope Point | 169,856 | — | — | — | — | — | — |
| 130 | Egypt Bay | 204,802 | — | — | — | — | — | — |
| 134 | Southend | 526,443 | 726,111 | 384,510 | 639,819 | 415,800 | 689,202 | 381,220 |
| | | O. D.+ 1·89 | O. D.+10·20 | O. D.− 5·70 | O. D.+ 6·70 | O. D.− 3·20 | O. D.+ 8·70 | O. D.− 5·80 |

8582. Upon this Table M 2 are the heights you have just given above Ordnance datum shown?—Yes, the heights are all given upon the table as well as the areas.

8583. Will you give the sectional areas at mean tides?—They are given in square feet. At Teddington it is 1,601 square feet, and then you will see below that the height I have already named is given O.D. + 11·00; Chiswick, 5,102 square feet. Then there is given the height at Chelsea, O.D. + 4·00; St. Paul's Pier, 12,358 square feet; Deptford, 22,280 square feet, with the height below it. Then there is one at No. 74 on my longitudinal section of 25,969 square feet. North Woolwich, 31,257 square feet; Barking, 43,993 square feet; Crossness, 50,200 square feet; Erith, 70,475 square feet; Erith piers, 69,558 square feet; Purfleet, 62,503 square feet; section 99, 65,903 square feet; Gravesend, 96,674 square feet; Gravesend "Ship and Lobster," that is just a little below, 110,299 square feet; Hope point, 169,856 square feet; Egypt Bay, 204,802 square feet; Southend, 526,443 square feet.

8584. Now you have prepared, I know, a longitudinal section showing the absolute high and low water heights; is that the same section as is before the chairman, or is it another?—It is another section; the sections are not put in, but the areas are all given below the heights.

8585. The areas in the further column of this table M2 are the areas at absolute high and low waters of the tide?—Yes, upon the 14th and 22nd of September and the 30th of November, the days upon which the chlorine samples were taken, the areas are given and the heights from which they have been calculated are given. I do not think it is worth while reading the whole of the table.

(*Sir John Coode.*) The table is perfectly clear and explicit.

8586. (*Mr. Balfour Browne.*) Have you carefully considered all the facts and figures which have been produced in this case?—I have, and also those which were got together in the Mud Case.

8587. And are you in a position to support the position of the Port Sanitary Authority that a nuisance is caused by the discharge of the sewage of the Metropolitan Board of Works at Barking and Crossness?—Yes, I think that at certain times of the year, in very dry weather, there must be a very great nuisance.

8588. You said in "dry weather," do you mean dry or hot weather?—Dry and hot weather.

8589. Before going to the outfalls, let me ask you if you have anything to say as to the river between bridges?—Yes, between bridges it is evident that a gradually increasing nuisance is threatened. Although it may be admitted that a great improvement between bridges has resulted from the taking of the sewage down to the Barking and Crossness outfalls, a growing nuisance must arise because of the increase of the population having already overtaken the calculations that were made in 1858 when the scheme was laid down.

8590. That is the cause, but what is the effect?—The effect is that the storm overflows must come into action more frequently than was then contemplated.

8591. And when the storm overflows come into action the sewage gets into the river up here instead of down at Crossness?—Yes, no doubt.

8592. Have you anything to say with regard to what I may call the Grosvenor Road Pumping Station?—I believe that that pumps direct into the river very frequently, but I have not seen it myself.

*Mr. Bidder* objected to the evidence.

8593. (*Mr. Balfour Browne.*) At any rate, your evidence is this: that the nuisance from the discharge at the storm overflows is an increasing nuisance?—It must be.

8594. And that because the population of the metropolis has already overtaken and surpassed the number for which the works were originally designed?—Yes, the fact of an increase in population of 500,000, tells in two ways, not only in increasing the actual quantity of sewage, but in another way. If there are 500,000 people more in London now than was reckoned upon, then there must be a very large area now covered with roads and buildings which was then open country, and from which a very small proportion of the rain falling would then have got into the sewers. Now instead of getting 5 or 10 per cent. you may get 60 or 80 per cent. of the rain falling off the roofs and the roads and paved areas, and that tends to gorge the sewers, and cause overflows.

8595. That you look upon as an addition to the sewage proper?—I do. Then take the case of Hampstead, a district I know very well, a district in which for the neighbourhood of London the roads are very steep, the rain that falls gets into the sewers in a very short time indeed.

8596. Whenever the sewers become gorged, then of course the storm overflows come into action and carry out the sewage into the river?—Yes.

8597. Have you anything to say with regard to the south side. A smaller provision I think was made

*Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.*

7 Feb. 1883.

upon the south side for the rainfall on account of the sparse population?—Yes, a smaller provision was made upon the south in 1856, or when the scheme was designed, than upon the north. Over some part of the area only an eighth of an inch was intended to get in instead of a quarter of an inch.

8598. Would you tell us the number of the population that the works were originally designed for. Mr. Latham gave it in his evidence as 3,448,500 persons?—Yes, I have taken that figure from the Report of the 6th April 1858.

8599. Speaking broadly, how many people may now send their sewage into the outfalls?—About half a million more, taking the two sides.

8600. (*Mr. Bidder.*) You say "may now"?—And do. There is a very small area I believe which is not drained into the sewers, but nothing of any extent.

8601. (*Mr. Balfour Browne.*) What percentage would that be of excess over that which was calculated for?—About 14 per cent. in excess of what was calculated as being the number to be provided for by the works.

8602. And the effect of that, as you have clearly pointed out, would be that there is less room in the intercepting sewers for the sewage, and that consequently the storm overflows have been called much more frequently into action than they would have been if their capacity had been more liberal in the first place?—Yes.

8603. You have already explained that this operates in two ways:—first of all, the increased population contributes a much larger amount of sewage; and secondly, that that which was open land formerly is now built upon, and contributes very much to the gorging of the sewers?—Very much so indeed.

8604. You have stated 14 per cent. as being the excess of population over the original provision. Can you give us any parallel city to illustrate your percentage?—You may say that the sewage of a city as large as Liverpool or Manchester has been added to the metropolis beyond what was intended.

8605. Therefore recurring to your remark with respect to the state of the river between bridges, something has happened or is happening between bridges which was not contemplated when the Metropolitan Drainage Scheme was laid out?—That is so, and that must be a growing evil as the population increases.

8606. Is there anything worthy of consideration in the fact that the subsoil water is getting into the sewers on the southern side of the Thames?—According to the figures which have been given, there appear to be about 50 gallons per head getting into the sewers upon the south side as against 30 gallons upon the north, and I can see no other mode of explaining it than that it arises from leakage as Mr. Latham stated.

8607. (*Sir John Coode.*) You do not mean 50 gallons a head in addition to what gets in upon the northern side, but 50 as against 30?—Yes, 50 gallons altogether.

8608. (*Mr. Bidder.*) I suppose that is derived from the same source as Mr. Latham stated?—Yes; I do not suppose for a moment that that leakage gets into the main intercepting sewers, because I know they were exceedingly well done; but that it gets into some of the local contributing sewers.

8609. (*Mr. Balfour Browne.*) Your view is that it does not get into the main intercepting sewers but into the contributing sewers; but at all events, wherever it gets in, there it is?—It gets in; I take it from Sir Joseph Bazalgette's own statement.

8610. (*Mr. Bidder.*) Would you show us where Sir Joseph Bazalgette says that it gets in?—It was stated by him upon the Mud Inquiry.

8611. (*Mr. Balfour Browne.*) It is in the evidence of the 12th July, page 735. (*To the witness*) Now if that 20 gallons per head is in the sewer, that adds another means of gorging besides the two that you have already described?—Yes, it amounts to adding the sewage of a population equal to two-thirds of the number of people, being 1,308,738, now using the sewer; that is to say, to adding an amount of sewage equal to that of 872,000 people upon the south side.

8612. (*Sir John Coode.*) But not adding that amount of pollution?—No; adding that amount of sewage, it puts into the sewers, a sewage equal to that of two-thirds of the population that is now using them.

8613. (*Mr. Balfour Browne.*) Even if it is only water put into the sewers it will tend to send the sewage out up here?—Yes, it charges the sewers to such an extent that they cannot hold the quantity of rainfall that was contemplated, and therefore the storm overflows come into action more frequently.

8614. It also, of course, has the effect of making the sewage weaker in dry weather?—Yes, no doubt.

8615. Having dealt with the river between bridges, let us go down to the outfalls between Barking and Crossness; how does the excess of the population operate upon the outfalls there?—First, of course, in increasing the actual volume of sewage beyond what was provided for.

8616. That is the first thing?—Yes; secondly, it affects the reservoirs. The reservoirs were calculated to hold their sewage during nine or ten hours of every tide, so that it should be only let out during 2½ or 3 hours. If the volume of sewage has thus increased, then the storage is practically diminished, and the discharge must go on during a longer time.

8617. To put it shortly, the reservoirs must be too small?—The reservoirs must be too small.

8618. Although I suppose when they were built the Board calculated upon some increase in the population?—Certainly they provided for a very large increase in the population, but the population has surpassed that estimated increase, and to a large extent the reservoirs must be too small now.

8619. And therefore, there again, whether it is really sewage that gets into the pipe or merely clean subsoil water, the capacity of the reservoirs will tell, because the discharge will require a longer period?—Yes.

8620. Have you a third conclusion?—I am now referring to the conclusion of Messrs. Bidder, Hawksley, and Bazalgette, in their report. I refer to their remark, that they provided for three and a half millions of people. I think I have said all upon that point which I desired to say.

8621. According to the view which I understand you to present to the Commission, it was never contemplated in 1858 that the works then intended to be constructed would be sufficient and satisfactory for a population so much in excess of the then population as we have now?—That is so. Messrs. Bidder, Hawkesley and Bazalgette say, in their report of 1858, that the plan "admits of indefinite extension and "adaptation to future necessities," and I think the time has already come when the works want adapting so as to alter them to present circumstances.

8622. I think we now pass to another branch of the subject?—I think the question of deodorisation ought to be gone into, as it was clearly intended that something should be done in that direction.

(*Chairman.*) I think that would fall in with the second part of our inquiry.

(*Mr. Balfour Browne.*) We are not going into any proposal for the future, but are only proposing to show what was intended to be done when these works were sanctioned.

8623. (*To the witness.*) You have examined the reports of Sir Joseph Bazalgette?—I have read all the reports, I think.

8624. And especially those of April, May, and September, 1856?—Yes; I find in Sir Joseph Bazalgette's reports in April, May, and September, 1856, upon the northern and southern outfalls, that he seemed to think then that deodorisation would not be necessary if the outfalls were made so low down as at Barking, that is the tenour of his reports.

8625. After the report of the Government Referees, dated the 30th July, 1857, Sir Joseph Bazalgette had

associated with him, as we have heard so often, Messrs. Bidder and Hawksley?—Yes.

8626. And those gentlemen reported to the Metropolitan Board of Works upon the 6th of April, 1858; you know what they said?—They went further than Sir Joseph Bazalgette did in his own reports; they talked of deodorising the sewage, and of spending 20,000*l.* a year in so doing.

(*Chairman.*) I think it would be best to refer to the report at once.

8627. (*Mr. Balfour Browne.*) The report contains an estimate at page 145. I think you will find these words:—"The sewage due to the present population "of the metropolis, including some rainflow, amounts "to about 80,000,000 gallons per diem"?—They go a little further than Sir Joseph Bazalgette did.

8628. The report proceeds: "the cost of the "application of the lime process to this quantity of "sewage would therefore be 40,000*l.* per annum; "but as in the case of the Metropolis there is "clearly no advantage, practical or theoretical, to be "obtained by the use of this process during the six "colder months of the year, we estimate the extreme "cost at only 20,000*l.* per annum. If, however, the "sewage be discharged at Barking Reach and "Crossness Point, into deep water, and with the "earlier portion of the descending tide, we believe "the process will not be needed during even the "hotter months, except, perhaps, under very "occasional and very exceptional conditions of the "river." That bears out what you said that they went a little further than Sir Joseph Bazalgette?—Yes. Then the Referees criticised that report, and Messrs. Bidder, Hawksley, and Bazalgette replied again upon the 20th of July, 1858, with what they called "brief observations," and in this document they went still further.

8629. Will you refer to the "brief observations" upon the 7th page, and read the eighth observation?—This is a curiously worded paragraph:—"The "referees, without being aware of the system upon "which the terminal reservoirs are intended to be "worked, object to their size." Then they go on to say:—"They will contain a tide full of sewage "proper, including maximum drainage, but during "rains it is intended to use them as depositing "reservoirs, allowing the clarified water to pass "slowly through the internal chambers in warm "weather in a fully deodorized state, but in cold "weather without being more than sufficiently limed "to carry down the suspended matter. The reservoirs "were designed on this principle, and we have no "doubt will work effectually." I read that to mean this,—that the sewage is to be so treated in warm weather that it would be discharged in a fully deodorized state, and that in cold weather it is to be so far treated that the suspended matter would be precipitated and retained and not sent into the river.

8630. That is your understanding of the paragraph?—I cannot make it mean anything else. Then there are certain Conclusions to this paper, and the 5th, 6th, and 8th of those conclusions bear out the interpretations I have given.

8630*a*. Will you just refer to anything that you think does that?—The 5th conclusion is:—"That "under the peculiar local circumstances of the "metropolis, it is more economical to pump and "deodorise (wholly or partially) than to convey the "sewage by deep channel gravitation to Sea "Reach." The 6th conclusion is:—"That the "expense of deodorising has been greatly magnified "in the referees' answer to our report." The 7th is:—"That the process of deodorisation may be, and "is at Leicester, so conducted as not to give off any "noxious emanations." The 8th conclusion is:—"That the supernatant liquid will not become putre-"scent in the river." From that I judge that it was clearly intended that the solids should be precipitated, and that only the supernatant liquid should go into the river.

8631. Now upon the 12th August 1859, the last having been 1858, Dr. Hofmann and Dr. Frankland, reported to the Metropolitan Board of Works?—Yes, they did; they reported as to the "selection from the "various schemes proposed for the deodorisation of "sewage of a process combining both efficiency and "economy." They were specialy requested to report.

8632. These gentlemen, I think, made a recommendation, but what you want to refer to is something on page 7 of their report of the 12th August 1859, what do they say?—They say: "The sewage "discharged at Barking Creek and Crossness Point "would probably not require deodorisation, except "during the hot season of the year, say, during three "months." Then they go on to give the cost and they say: "Supposing the deodorisation to be "effected by perchloride of iron, the disinfection of "this portion of the sewage at the present rate of "flow would involve an expenditure of 11,620*l.* for "the three months. We are, however, of opinion, "that in practice the sewage discharged into the "river at this distance from the metropolis would "rarely require deodorisation for so long a period as "three months. In fact, we are not without hope "that the sewage, supposing it to arrive at these "outfalls in a condition similar to that in which it is "at present discharged from the King's Scholar's "Pond sewer, would, *when properly freed from "suspended matter*, only require deodorisation under "particularly unfavourable circumstances." They clearly contemplate the removal of suspended matter.

8633. I think they go on to say:—"It remains "only to draw particular attention to the importance "of discharging the sewage into the river as free "from mechanically suspended matter as possible"?—Yes.

8634. "We have found that this suspended matter, "when separated even from the deodorised sewage, "rapidly passes in warm weather into a state of "active putrefaction"?— Yes, they emphasise that very much; they emphasise strongly the recommendation that the solids should be removed, therefore, both the engineers and chemists and all the advisers of the Board at that time contemplated the taking out of the solids before the sewage was discharged.

8635. They contemplated that, but they also contemplated that in hot weather there should be deodorisation?—They did.

(*Chairman to Mr. Balfour Browne.*) We do not wish to stop you in any way, but you will bear in mind that this is merely evidence of the opinions which were expressed by scientific men as to what would or would not be necessary 25 years ago. We do not like to stop you, but you may take it as shortly as you can, because it is only remotely connected with the question which we have to inquire into. It is doing us service to call our attention, in passing, to these matters, no doubt they might be very useful in cross-examination hereafter.

(*Mr. Bidder.*) Those were the speculations of scientific men before the work was done as to what would be the result; but it is hardly worth while to go this roundabout way to get at it when we can give what the actual results are.

(*Chairman.*) We had been rather waiting for you to take the objection.

8636. (*Mr. Balfour Browne to the witness.*) Whatever those opinions were, I want to ask your opinion, do you think that the advice of the engineers and chemists was good sound advice, and ought to have been acted upon?—Yes, I do.

8637. And is it your view that the discharge of sewage in its crude untreated condition into the river creates a nuisance which ought to be avoided by some such process as that indicated in the opinion of the engineers?—Yes, I do; a nuisance not only by its discharge into the river at the time, but subsequently on account of the deposit of organic matter in the river itself, and on the mud banks which become exposed at low water. The sewage discharge, at the time of discharge, is itself a nuisance greater of course in very

*Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.*

7 Feb. 1883.

hot weather, but a subsequent nuisance may arise from the fact that some of the organic matter is deposited in the river which, in very hot weather, comes up to the surface and causes an abominable nuisance.

8638. And those are the facts as they have been described by some of the witnesses?—Yes.

8639. Looking at the information which has been got together by the Port Sanitary Authority, and looking to the physical condition of the river, do you think that it points necessarily, altogether apart from the evidence which has been given before this Commission, to the creation of a nuisance?—I do.

8640. What do you found that opinion upon—do the float experiments, in the first instance, give you any information upon which you can found that opinion?—Yes.

8641. What do you say with regard to the float experiments from 1 to 7, taking the northern outfall?—They show of course what everybody knew to a certain extent, that the water after passing down the river is brought up again, and must bring with it sewage—they show also that at certain times of the tide near the top and bottom of the tide the velocity of the current is much less than it is in the intermediate part of it, that is to say, in the middle of the tide, and during that time my opinion is that a considerable deposition of the solids takes place.

8642. The fact that there is a time of rest as it were in the river gives an opportunity for the solids going to the bottom?—Yes; if you were to plot any of those diagrams you would find that for an hour or two at the top of the tide the curve is a very flat one—that as it begins to run down it becomes sharper, and then it is flatter towards the bottom, and as the tide slacks it gives a great opportunity for the deposit of solids on the bed of the river.

8643. That you get from the diagrams?—Yes, the diagrams would show that if they were drawn upon a larger scale.

8644. You say that altogether apart from any deductions which were given by Mr. Latham?—Yes.

8645. Is there any other remark which you want to make about these experiments?—No, I do not know that I do—it has all been so fully gone into before.

8646. What you say with regard to the flat curve at the top is also true as to the flat curve at the bottom?—Yes.

8647. That both at high water and low water the river at Barking is to some extent a settling tank?—Yes, and any point in the river above and below Barking, when the water comes to a condition almost of rest.

8648. Is another result which you arrive at, from these float experiments, that a segment of the river is polluted to an undue and abnormal extent and becomes a local nuisance to the neighbourhood on the banks?—Clearly that must be so. Take the northern outfall; when the sluices are open at the top of the tide, and when for half-an-hour there is practically no current—the whole river is covered with sewage and for a short time it causes a great nuisance to the locality.

8649. I understand that in your opinion, in estimating the rate at which the sewage goes out to sea, the float experiments alone, taken without conjunction with the chlorine tests, would give you no information?—No, practically not as regards the progress to the sea—the progress to the sea has been worked out entirely from the two factors, the displacement by upland water and the displacement by mixing with the sea water.

8650. And the rate of progression must be calculated from those data and not from the float observations?—Not from the float observations.

8651. The land water, as you say, acts simply by displacement?—Yes.

8652. The influx and reflux of the tide has an entirely different action upon the carrying of the sewage out to sea?—Yes, the influx of the tide diminishes the area available for the passage of the land water, and therefore increases its velocity.

8653. Supposing there was no sea water flowing in and out, but that the Thames was a river falling into a lake or tideless sea, then you could calculate the rate of progress to the lake by the land water coming over Teddington Weir, and the sectional area of the river?—Yes, if it had to pass into a lake, and the channel of the river were the same slope and the same sectional area all the way down, the progress down the river would be the same day by day.

8654. But if the sectional area were increased, the progress would be diminished?—Yes, in an inverse ratio to the increase of the sectional area.

8655. So that the further you got down the tidal river the slower the progress would become, whereas, as a fact, it becomes quicker?—Yes, it would be slower; the same quantity of water would be displaced at the low end, but seeing that the sectional area was larger, the distance passed through would be so much shorter.

8656. Suppose that enough water comes in at the head of the channel in a day to fill five miles of river, and the river were 50 miles long, there would be the same amount of water pass out of the river at Southend, only it would be water that had passed in at the head 10 days before?—Clearly, the water that comes in to-day would displace water which came in 10 days before at the upper end.

8657. And of course of the same bulk?—The same volume of water would go out, but not the same length in the river channel.

8658. The channel of the river is not of equal sectional area throughout, but widens, as you have said, and deepens at the same time?—Yes.

8659. You have told us that under those circumstances, looking at the displacement alone, the rate of progression would inversely diminish?—Yes.

8660. Suppose the sectional area of the last half mile near the mouth were 10 times the sectional area of the top five miles, then the length of the segment of water displaced would be only half a mile instead of five miles long?—Yes, that is so.

8661. That makes the mere displacement theory perfectly clear?—Yes.

8662. And in calculating the rate at which sewage is carried out to sea, though you take in another element, yet you must always use displacement as a factor?—Yes.

8663. The amount of water coming in over Teddington Weir and other sources varies every day?—Yes.

8664. Now the second factor is, what in Mr. Latham's evidence has been called "mixture" and which is due to the entrance into the river of Lea water?—Yes.

8665. I want you to explain your view of this to the Commission. This mixture takes place whenever the fresh and the salt water come together, I suppose?—Yes.

8666. Is it facilitated by the stirring action of currents and eddies?—The mixture takes place by the eddies, the currents, the wind, and all things of that kind.

8667. (*Sir John Coode.*) And the screws of steamers, I suppose, have something to do with it?—No doubt they would help to mix the waters.

8668. (*Mr. Balfour Browne.*) The way in which these elements induce progression to the sea can, I think, be explained by means of a diagram which you have prepared?—It has helped to explain it to my mind (*shewing a diagram*). Let us suppose that the 100 black spots upon what I call the first position are molecules of fresh water surrounded by salt water, and that then they are moved down the river in the course of a tide to the second position. In the course of being moved down and coming up again upon the next tide they are surrounded by a larger number of particles of salt water, or have aggregated around them a larger amount of salt water. Then on their return up the river into position 3, having been so increased in size, they cannot get into the position they held at first, and therefore some of the body

must overflow down the river. (*Explaining the same upon the diagram.*) I may say these areas are plotted quite hypothetically.

8669. (*Chairman.*) Why is it that they cannot get into the same position coming up?—Because they have so much more sea water around them, and occupy a greater bulk.

8670. (*Sir John Coode.*) Do you mean each dot to represent a molecule of sewage or of fresh water?—Of fresh water, and not of sewage.

8671. (*Mr. Balfour Browne.*) As I understand, it is not that these 100 dots could not occupy the same place, but that, having got down further, they aggregate and associate themselves with thousands of salt particles, and the body then cannot go into the same space, but only a portion of it; a portion overlaps, and the progression is to be measured by the position of the mean centre moving down the stream?—That is so; it is only a way of explaining how it arises. The *measurement* of the progression is made by means of the chlorine tests.

8672. Of course this is not the measurement at all?—No, that is only a diagram that was made to explain it to one's own mind.

(*Sir John Coode.*) I think we had better take the chlorine tests, for whatever they may be worth, in preference to that hypothetical diagram.

8673. (*Mr. Balfour Browne.*) Mr. Mansergh has adopted the chlorine tests implicitly. (*To the witness.*) You have worked upon the chlorine tests with regard to the mode of progression?—I have adopted them; I did not invent them at all. Whoever did, has, in my opinion, done great service, but I have adopted them.

8674. This is merely to show hypothetically how, diagrammatically, it can be made to appear?—Yes.

8675. The very next thing I was going to argue was that the extent of the mixture between fresh water and sewage and salt water is to be measured entirely by the chlorine test?—Yes, exactly. I think the chlorine determinations give a mode of measuring the mode of progression which was never thought of before.

8676. You have told the Commission that if it were merely by displacement in a lake without tidal influences the rate of progress would be diminished. As a fact, I think the chlorine tests show that the rate of progress is increased?—Yes, the rate of progress is increased, because the land water has not to displace the water in so large a section. Already any section of the river is occupied by sea water, and therefore the land water has to get through in a smaller section, and must therefore get through in a shorter time. There is no impounding of the water; there is no more water in one month than in another month.

8677. If the sectional area were the same all through the 50 miles, it would progress at the same rate every day?—Yes.

8678. If the sectional area is increased, the progress is diminished?—Yes.

8679. If the sectional area is diminished the progress is increased?—Yes.

8680. Now I understand you to say that the incoming of the tide has the effect of diminishing the sectional area?—It has the effect of diminishing the sectional area which the fresh water has to pass through.

8681. And therefore the incoming of the tide, as a physical fact, has the effect of expediting the progress of the fresh water and the sewage to the sea?—Yes.

8682. You have prepared some other tables, I think, which you wish to lay before the Commission?—I have prepared M. 3*a*, M. 3*b*, M. 3*c*, and M. 3*d*.

(*The following were handed in. See pages* 290, 291, 292, 293.)

8683. First with regard to M. 3*a*, will you kindly proceed to explain that table?—The object of preparing these tables was to make out the time in which the land water with the sewage in it would progress to the sea, and I have worked upon somewhat different lines from Mr. Baldwin Latham for the purpose of explaining it, I think, in a clear way, and of checking our relative results.

*Mr. J. Mansergh. M. Inst. C.E., F.G.S., F.M.S.*

7 Feb. 1883.

8684. You have taken, I see, two days, the 14th of September and the 30th of November?—The 14th of September was a day on which there was a comparatively small quantity of land water, and the 30th of November was a day on which there was a comparatively large quantity coming down.

8685. Those were two of the days when the chlorine tests were taken from the samples?—Yes, there was another day, the 22nd of September, but I thought those two enough to deal with.

8686. In this table M. 3*a* I see the river is divided into 12 divisions, six above Crossness and six below?—Yes, I take Crossness as the middle point, because there the whole of the sewage has come into the river, and there happen to be 30 miles below Crossness and a little over 30 miles above Crossness. I have divided the river below Crossness into six divisions of five miles each, and above Crossness into five divisions of five miles each, and one of 7·15 miles adjoining Teddington. In the first column I put the chlorine found by analysis at Teddington, Chiswick, St. Paul's Pier, Deptford, North Woolwich, Barking, Erith, Gravesend, and Southend. Then I have interpolated, to the best of my judgment, the mean chlorine in that first division which I have called, in the table, the sixth division above Crossness. You will find it both at high water and low water. Taking high water, the sixth division gives 3·2, the fifth 4·7, the fourth 107·7, and so on; you will find the interpolated chlorine under the *length* of the division in each case. Then in column No. 3. I give the content of the river in each division; that is taken out from the cross sections; I have taken out a large number of cross sections, so that this content represents at high water upon the 14th of September very nearly,—as nearly as can be,—the quantity of water in each of the divisions.

8687. And those would correspond with the longitudinal sectional divisions?—Yes, in the sixth division you will find 171,000,000 cube feet, and in the fifth division 264,000,000 cube feet.

8688. The sixth division is the 7·15 miles?—Yes. Now, going to the first division below Crossness, you get a content of 2,342,000,000 cube feet, and in the division immediately above Southend 14,430,000,000 cube feet; in each of those five mile divisions you have the content in the third column. Then, working from the chlorine, in the fourth column I got the percentage of sea water.

8689. Is it not well to call attention to the second item upon the sheet, the quantity of water coming over Teddington weir upon that date?

(*Chairman.*) We have had that in the other table.

(*Mr. Balfour Browne.*) But it may be material here, I think.

(*Witness.*) That is stated here as 119,990,880 cube feet in 24 hours, and the quantity of sewage I have estimated as coming in at Barking and Crossness is given below, being 14,760,000 cube feet at Barking and 11,240,000 cube feet at Crossness in the 24 hours. Now column 4 gives the percentage of sea water in each of those divisions; there is nothing in the first, it is too small to be given; in the second division it is 0·2, and in the division immediately above Southend 95·7, showing a gradual increase of salt water as you progress down the river. Then in the fifth column the actual quantity of sea water is given as worked out from these percentages; in the fifth division above Crossness it is $\frac{1}{3}\frac{1}{0}\frac{1}{0}$th of the whole quantity. In the last division above Southend you get 95·70 of sea water, so that you get out of 14,430,000,000 cube feet, land and sea water, 13,809,000,000 cube feet of sea water.

8690. Is that column worked out from the first by the percentage of sea water?—Yes. Now column No. 6. gives the percentage of upland water.

8691. There is an important note to that, the column is headed "Percentage of upland water, in-

(M 3A.)

## RIVER THAMES, 14th September 1882.

Quantity of Water coming over Teddington Weir 119,990,880 cube feet in 24 hours.

TABLE showing the RATE of PROGRESS towards the SEA due to the UPLAND and TIDAL WATER.

*N.B—The River is divided into Six divisions of 5 miles each from Crossness down to Southend, and Five divisions of 5 miles each and One of 7·15 miles from Crossness up to Teddington.*

The measured quantity of Upland water entering the River in each division is calculated as coming in at the upper end of that division,—the sewage discharged at Barking is calculated at 14,760,000 cube feet, and at Crossness 11,240,000 cube feet in 24 hours.

Upland water is taken as containing 1·7 parts of Chlorine, Sewage 10 parts of Chlorine, and Sea Water 1,961 parts of Chlorine per 100,000 parts.

ABSOLUTE HIGH WATER.

| 1. Chlorine found by Analysis. Parts in 100,000. | 2. DIVISIONS OF THE RIVER. | | 3. Content of River in each Division. | 4. Per-centage of Sea Water (from Chlorine). | 5. Quantity of Sea Water in each Division. | 6. Per-centage of Upland Water including Sewage* (from Chlorine). | 7. Quantity of Upland Water and Sewage in each Division.* | 8. Quantity of Upland Water at Top of each Division (by Gaugings). | 9. Per-centage of Sewage in Upland Water and Sewage.* | 10. Quantity of Sewage in each Division* $\left(\frac{\text{Col. 7} \times \text{Col. 9}}{100}\right)$ | 11. Per-centage of Sewage in whole Content of each Division.* | 12. Time taken to Progress through each Division (Col. 7÷Col. 8) | 13. Total Time Teddington to Crossness. / Total Time Crossness to Southend. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEDDINGTON. 1·7 | TEDDINGTON. | | Cube Feet. | | Cube Feet. | | Cube Feet. | Cube Feet per Day. | | Cube Feet. | | Days. | Days. |
| | 6th Division above Crossness<br>Mean Chlorine in 6th Division (interpolated) 3·2. | 7·15 miles | 171,172,584 | Nil. | Nil. | 100·00 | 171,172,584 | 122,860,800 | — | — | — | 1·39 | 1·39 |
| CHISWICK. 4·7 | 5th Division above Crossness<br>Mean Chlorine in 5th Division (interpolated) 4·7. | 5 miles | 264,609,840 | 0·20 | 529,220 | 99·80 | 264,080,620 | 122,860,800 | — | — | — | 2·15 | 3·54 |
| | 4th Division above Crossness<br>Mean Chlorine in 4th Division (interpolated) 107·7. | 5 miles | 420,863,520 | 5·40 | 22,726,630 | 94·60 | 393,136,890 | 125,940,960 | — | — | — | 3·16 | 6·70 |
| ST. PAUL'S PIER. 210·7 | 3rd Division above Crossness<br>Mean Chlorine in 3rd Division (interpolated) 324·3. | 5 miles | 679,749,840 | 16·50 | 112,158,724 | 83·50 | 567,591,116 | 125,940,960 | — | — | — | 4·51 | 11·21 |
| DEPTFORD. 438·0 | 2nd Division above Crossness<br>Mean Chlorine in 2nd Division (interpolated) 554·0. | 5 miles | 1,025,758,800 | 28·20 | 289,263,982 | 71·80 | 736,494,818 | 130,059,360 | — | — | — | 5·66 | 16·87 |
| N. WOOLWICH. 671·0 | 1st Division above Crossness<br>Mean Chlorine in 1st Division (interpolated) 708·0. | 5 miles | 1,649,208,000 | 36·00 | 593,714,880 | 64·00 | 1,055,493,120 | 148,422,240 | 10·00 | 105,549,312 | 6·40 | 7·11 | 23·98 |
| BARKING. 745·0 | | | | | | | | | | | | | CROSSNESS. |
| | CROSSNESS. | | | | | | | | | | | | |
| ERITH. 1031·0 | 1st Division below Crossness<br>Mean Chlorine in 1st Division (interpolated) 1031·0. | 5 miles | 2,342,144,640 | 52·50 | 1,229,625,936 | 47·50 | 1,112,518,704 | 161,836,960 | 16·00 | 178,002,993 | 7·60 | 6·90 | 6·90 |
| | 2nd Division below Crossness<br>Mean Chlorine in 2nd Division (interpolated) 1266·1. | 5 miles | 2,802,647,760 | 64·50 | 1,807,707,805 | 35·50 | 994,939,955 | 172,980,800 | 15·00 | 149,240,993 | 5·30 | 5·75 | 12·65 |
| GRAVESEND. 1502·0 | 3rd Division below Crossness<br>Mean Chlorine in 3rd Division (interpolated) 1502·0. | 5 miles | 3,265,025,280 | 76·60 | 2,501,009,364 | 23·40 | 764,015,916 | 172,980,800 | 15·00 | 114,602,387 | 5·50 | 4·42 | 17·07 |
| | 4th Division below Crossness<br>Mean Chlorine in 4th Division (interpolated) 1645·0. | 5 miles | 5,166,134,160 | 83·90 | 4,334,386,560 | 16·10 | 831,747,600 | 172,980,800 | 15·00 | 124,762,140 | 2·40 | 4·81 | 21·88 |
| | 5th Division below Crossness<br>Mean Chlorine in 5th Division (interpolated) 1716·0. | 5 miles | 7,283,408,880 | 87·50 | 6,372,982,770 | 12·50 | 910,426,110 | 172,980,800 | 15·00 | 136,563,916 | 1·90 | 5·26 | 27·14 |
| SOUTHEND. 1931·0 | 6th Division below Crossness<br>Mean Chlorine in 6th Division (interpolated) 1877·0. | 5 miles | 14,430,007,680 | 95·70 | 13,809,517,350 | 4·30 | 620,490,330 | 172,980,800 | 15·00 | 93,073,546 | ·65 | 3·59 | 30·73 |
| | SOUTHEND. | | | | | | | | | | | | SOUTHEND. |

* It is assumed for the purpose of calculation but *not admitted*, that there is no Sewage in the River above Barking.

# RIVER THAMES, 14th September, 1882.

Quantity of Water coming over Teddington Weir 119,990,880 cube feet in 24 hours

TABLE showing the RATE of PROGRESS towards the SEA due to the UPLAND and TIDAL WATER.

*N.B.—The River is divided into Six divisions of 5 miles each from Crossness down to Southend, and Five divisions of 5 miles each and One of 7·15 miles from Crossness up to Teddington.*

The measured quantity of Upland water entering the River in each division is calculated as coming in at the upper end of that division,—the sewage discharged at Barking is calculated at 14,760,000 cube feet, and at Crossness 11,240,000 cube feet in 24 hours.

Upland water is taken as containing 1·7 parts of Chlorine, Sewage 10 parts of Chlorine, and Sea Water 1,961 parts of Chlorine per 100,000 parts.

ABSOLUTE LOW WATER.

| 1. Chlorine found by Analysis. Parts in 100,000. | 2. DIVISIONS OF THE RIVER. | 3. Content of River in each Division. | 4. Per-centage of Sea Water (from Chlorine). | 5. Quantity of Sea Water in each Division. | 6. Per-centage of Upland Water including Sewage* (from Chlorine). | 7. Quantity of Upland Water and Sewage in each Division.* | 8. Quantity of Upland Water at Top of each Division (by Gaugings). | 9. Per-centage of Sewage in Upland Water and Sewage.* | 10. Quantity of Sewage in each Division* (Col. 7 × Col. 9 / 100) | 11. Per-centage of Sewage in whole Content of each Division*. | 12. Time taken to progress through each Division (Col. 7 ÷ Col. 8) | 13. Total Time Teddington to Crossness. / Total Time Crossness to Southend. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEDDINGTON. 1·70 | TEDDINGTON. | Cube feet. | | Cube feet. | | Cube feet. | Cube feet per Day. | | Cube feet. | | Days. | Days. |
| | 6th Division above Crossness - - - - 7·15 miles<br>Mean Chlorine in 6th Division (interpolated) 1·8. | 39,827,304 | Nil. | Nil. | 100·00 | 39,827,304 | 122,860,800 | — | — | — | 0·32 | 0·32 |
| CHISWICK. 1·90 | 5th Division above Crossness - - - - 5 miles<br>Mean Chlorine in 5th Division (interpolated) 1·9. | 62,618,160 | Nil. | Nil. | 100·00 | 62,618,160 | 122,866,800 | — | — | — | 0·51 | 0·83 |
| | 4th Division above Crossness - - - - 5 miles<br>Mean Chlorine in 4th Division (interpolated) 3·0. | 114,734,400 | 0·10 | 114,734 | 99·90 | 114,619,666 | 125,940,960 | — | — | — | 0·91 | 1·74 |
| ST. PAUL'S PIER. 4·10 | 3rd Division above Crossness - - - miles<br>Mean Chlorine in 3rd Division (interpolated) 26·55. | 214,782,480 | 1·20 | 2,577,390 | 98·80 | 212,205,090 | 125,940,960 | — | — | — | 1·68 | 3·42 |
| DEPTFORD. 49·0 | 2nd Division above Crossness - - - 5miles<br>Mean Chlorine in 2nd Division (interpolated) 114·5. | 375,004,080 | 5·80 | 21,750,237 | 94·20 | 353,253,843 | 130,059,360 | — | — | — | 2·72 | 6·14 |
| N. WOOLWICH. 180·0 | 1st Division above Crossness - - - - 5 miles<br>Mean Chlorine in 1st Division (interpolated) 249·5. | 684,087,360 | 12·60 | 86,195,007 | 87·40 | 597,892,353 | 148,422,240 | 10·00 | 59,789,235 | 8·70 | 4·03 | 10·17 |
| BARKING. 319·0 | | | | | | | | | | | | CROSSNESS. |
| | CROSSNESS. | | | | | | | | | | | |
| ERITH. 530·0 | 1st Division below Crossness - - - - 5 miles<br>Mean Chlorine in 1st Division (interpolated) 530·0. | 1,092,885,980 | 26·90 | 293,986,329 | 73·10 | 798,899,651 | 161,336,960 | 16·00 | 127,823,944 | 11·70 | 4·95 | 4·95 |
| | 2nd Division below Crossness - - - - 5 miles<br>Mean Chlorine in 2nd Division (interpolated) 794·0. | 1,515,441,840 | 40·40 | 612,238,503 | 59·60 | 903,203,337 | 172,980,800 | 15·00 | 135,480,501 | 8·90 | 5·22 | 10·17 |
| GRAVESEND. 1058·0 | 3rd Division below Crossness - - - - 5 miles<br>Mean Chlorine in 3rd Division (interpolated) 1058·0. | 1,901,870,240 | 53·90 | 1,024,838,559 | 46·10 | 876,531,681 | 172,980,800 | 15·00 | 131,479,752 | 6·90 | 5·07 | 15·24 |
| | 4th Division below Crossness - - - - 5 miles<br>Mean Chlorine in 4th Division (interpolated) 1293·3. | 2,695,606,320 | 65·90 | 1,776,404,565 | 34·10 | 919,201,755 | 172,980,800 | 15·00 | 137,880,263 | 5·10 | 5·31 | 20·55 |
| | 5th Division below Crossness - - - - 5 miles<br>Mean Chlorine in 5th Division (interpolated) 1411·5. | 3,648,268,240 | 72·00 | 2,626,753,133 | 28·00 | 1,021,515,107 | 172,980,800 | 15·00 | 153,227,266 | 4·20 | 5·91 | 26·46 |
| SOUTHEND. 1763·0 | 6th Division below Crossness - - - - 5 miles<br>Mean Chlorine in 6th Division (interpolated) 1676·0. | 7,720,814,640 | 85·40 | 6,593,575,703 | 14·60 | 1,127,238,937 | 172,980,800 | 15·00 | 169,085,840 | 2·19 | 6·52 | 32·98 |
| | SOUTHEND. | | | | | | | | | | | SOUTHEND. |

* It is assumed for the purpose of calculation, but *not admitted*, that there is no Sewage in the River above Barking.

The *mean* of Columns 13 in the High and Low Water Tables is to be taken as the time of progress towards the sea, on the assumption that the conditions prevailing on the 14th September are maintained during the whole period.
From Teddington to Southend the mean time is 48·93 days. From Crossness to Southend the mean time is 31·85 days.





Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.
7 Feb. 1883.

Mr. J. Massergh, M. Inst. C.E., F.G.S., F.M.S.

7 Feb. 1883.

(M 3c.)

## RIVER THAMES, 30th November 1882.

**Quantity of Water coming over Teddington Weir 685,936,800 cube feet in 24 hours.**

TABLE showing the RATE of PROGRESS towards the SEA due to the UPLAND and TIDAL WATER.

*N.B.—The River is divided into Six divisions of 5 miles each from Crossness down to Southend, and Five divisions of 5 miles each and One of 7·15 miles from Crossness up to Teddington.*

The measured quantity of Upland water entering the River in each Division is calculated as coming in at the upper end of that Division,—the sewage discharged at Barking is calculated at 14,760,000 cube feet, and at Crossness 11,240,000 cube feet in 24 hours.

Upland water is taken as containing 1·7 parts of Chlorine, Sewage 10 parts of Chlorine, and Sea Water 1,961 parts of Chlorine per 100,000 parts.

ABSOLUTE HIGH WATER.

| 1. Chlorine found by Analysis. Parts in 100,000. | 2. DIVISIONS OF THE RIVER. | 3. Content of River in each Division. | 4. Per-centage of Sea Water (from Chlorine). | 5. Quantity of Sea Water in each Division. | 6. Per-centage of Upland Water including Sewage* (from Chlorine). | 7. Quantity of Upland Water and Sewage in each Division.* | 8. Quantity of Upland Water at Top of each Division (by Gaugings). | 9. Per-centage of Sewage in Upland Water and Sewage.* | 10. Quantity of Sewage in each Division* $\left(\frac{\text{Col. 7} \times \text{Col. 9}}{100}\right)$ | 11. Per-centage of Sewage in whole Content of each Division.* | 12. Time taken to Progress through each Division. (Col.7÷Col.8.) | 13. Total Time Teddington to Crossness. / Total Time Crossness to Southend. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEDDINGTON. 1·70 | TEDDINGTON. | Cube Feet. | | Cube Feet. | | Cube Feet. | Cube Feet per Day. | | Cube Feet. | | Days. | Days. |
| | 6th Division above Crossness - - - - - 7·15 miles<br>Mean Chlorine in 6th Division (interpolated) 1·83. | 164,482,824 | Nil. | Nil. | 100·00 | 164,482,824 | 691,269,120 | — | — | — | 0·24 | 0·24 |
| CHISWICK. 1·95 | 5th Division above Crossness - - - 5 miles<br>Mean Chlorine in 5th Division (interpolated) 1·95. | 251,584,080 | Nil. | Nil. | 100·00 | 251,584,080 | 691,269,120 | — | — | — | 0·36 | 0·60 |
| | 4th Division above Crossness - - - - - 5 miles<br>Mean Chlorine in 4th Division (interpolated) 2·37. | 400,002,240 | Nil. | Nil. | 100·00 | 400,002,240 | 704,895,840 | — | — | — | 0·57 | 1·17 |
| ST. PAUL'S PIER. 2·80 | 3rd Division above Crossness - - - - 5 miles<br>Mean Chlorine in 3rd Division (interpolated) 11·40. | 643,645,200 | 0·50 | 3,218,236 | 99·50 | 640,426,974 | 704,895,840 | — | — | — | 0·91 | 2 08 |
| DEPTFORD. 20·00 | 2nd Division above Crossness - - - - 5 miles<br>Mean Chlorine in 2nd Division (interpolated) 69·12. | 977,351,760 | 3·50 | 34,207,312 | 96·50 | 943,144,448 | 734,857,760 | — | — | — | 1·29 | 3·37 |
| N. WOOLWICH. 118·25 | 1st Division above Crossness - - - - 5 miles<br>Mean Chlorine in 1st Division (interpolated) 135·25 | 1,579,987,200 | 6·80 | 107,439,130 | 93·20 | 1,472,548,070 | 759,306,240 | 1·90 | 27,978,413 | 1·77 | 2·00 | 5·37 |
| BARKING. 152·25 | | | | | | | | | | | | CROSSNESS. |
| | CROSSNESS. | | | | | | | | | | | |
| ERITH. 314·25 | 1st Division below Crossness - - - - - 5 miles<br>Mean Chlorine in 1st Division (interpolated) 314·25 | 2,247,152,160 | 15·90 | 357,297,193 | 84·10 | 1,889,854,967 | 796,709,600 | 3·30 | 62,335,214 | 2·78 | 2·37 | 2·37 |
| | 2nd Division below Crossness - - - - 5 miles<br>Mean Chlorine in 2nd Division (interpolated) 559·0. | 2,687,417,040 | 28·40 | 763,226,439 | 71·60 | 1,924,190,601 | 806,636,960 | 3·20 | 61,574,099 | 2·29 | 2·38 | 4·75 |
| | 3rd Division below Crossness - - - - 5 miles<br>Mean Chlorine in 3rd Division (interpolated) 804·0. | 3,126,071,520 | 40·90 | 1,278,565 252 | 59·10 | 1,847,508,268 | 806,636,960 | 3·20 | 59,120,265 | 1·89 | 2·29 | 7·04 |
| | 4th Division below Crossness - - - - 5 miles<br>Mean Chlorine in 4th Division (interpolated) 1048·0. | 4,913,839,920 | 53·40 | 2,623,990,517 | 46·60 | 2,289,849,403 | 806,636,960 | 3·20 | 73,275,181 | 1·49 | 2·84 | 9·88 |
| | 5th Division below Crossness - - - - 5 miles<br>Mean Chlorine in 5th Division (interpolated) 1416·0. | 6,898,407,120 | 72·20 | 4,980,649,941 | 27·80 | 1,917,757,179 | 806,636,960 | 3·20 | 61,368,230 | ·89 | 2·38 | 12·26 |
| SOUTHEND. 1785·00 | 6th Division below Crossness - - - - 5 miles<br>Mean Chlorine in 6th Division (interpolated) 1700·0. | 13,686,657,600 | 86·30 | 11,811,585,509 | 13·70 | 1,875,072,091 | 806,636,960 | 3·20 | 60,002,307 | ·44 | 2·32 | 14·58 |
| | SOUTHEND. | | | | | | | | | | | |

* It is assumed for the purpose of calculation but *not admitted* that there is no Sewage in the River above Barking.

# RIVER THAMES, 30th November 1882.

Quantity of Water coming over Teddington Weir 685,936,800 cube feet in 24 hours.

TABLE showing the RATE of PROGRESS towards the SEA due to the UPLAND and TIDAL WATER.

*N.B.—The River is divided into Six divisions of 5 miles each from Crossness down to Southend and Five divisions of 5 miles each and One of 7·15 miles from Crossness up to Teddington.*
The measured quantity of Upland Water entering the River in each Division is calculated as coming in at the upper end of that Division,—the sewage discharged at Barking is calculated at 14,760,000 cube feet, and at Crossness 11,240,000 cube feet in 24 hours.

Upland water is taken as containing 1·7 parts of Chlorine, Sewage 10 parts of Chlorine, and Sea Water 1,961 parts of Chlorine per 100,000 parts.

ABSOLUTE LOW WATER.

| 1. Chlorine found by Analysis. Parts in 100,000. | 2. DIVISIONS OF THE RIVER. | | 3. Content of River in each Division. | 4. Per-centage of Sea Water (from Chlorine). | 5. Quantity of Sea Water in each Division. | 6. Per-centage of Upland Water including Sewage* (from Chlorine). | 7. Quantity of Upland Water and Sewage in each Division.* | 8. Quantity of Upland Water at Top of each Division (by Gaugings). | 9. Per-centage of Sewage in Upland Water and Sewage.* | 10. Quantity of Sewage in each Division* (Col. 7 × Col. 9 / 100). | 11. Per-centage of Sewage in whole Content of each Division.* | 12. Time taken to Progress through each Division. (Col.7÷Col.8.) | 13. Total Time Teddington to Crossness. / Total Time Crossness to Southend. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEDDINGTON. 1·70 | TEDDINGTON. | | Cube Feet. | | Cube Feet. | | Cube Feet. | Cube Feet per Day. | | Cube Feet. | | Days. | Days. |
| | 6th Division above Crossness<br>Mean Chlorine in 6th Division (interpolated) 1·72. | 7·15 miles | 90,050,664 | Nil. | Nil. | 100·00 | 90,050,664 | 691,269,120 | — | — | — | 0·13 | 0·13 |
| CHISWICK. 1·75 | 5th Division above Crossness<br>Mean Chlorine in 5th Division (interpolated) 1·75. | 5 miles | 102,846,480 | Nil. | Nil. | 100·00 | 102,846,480 | 691,269,120 | — | — | — | 0·15 | 0·28 |
| | 4th Division above Crossness<br>Mean Chlorine in 4th Division (interpolated) 1·82. | 5 miles | 145,405,920 | Nil. | Nil. | 100·00 | 145,405,920 | 704,895,840 | — | — | — | 0·21 | 0·49 |
| ST. PAUL'S PIER. 1·90 | 3rd Division above Crossness<br>Mean Chlorine in 3rd Division (interpolated) 1·87. | 5 miles | 224,138,640 | Nil. | Nil. | 100·00 | 224,138,640 | 704,895,840 | — | — | — | 0·32 | 0·81 |
| DEPTFORD. 1·85 | 2nd Division above Crossness<br>Mean Chlorine in 2nd Division (interpolated) 2·47. | 5 miles | 378,451,920 | Nil. | Nil. | 100·00 | 378,451,920 | 734,657,760 | — | — | — | 0·52 | 1·33 |
| N. WOOLWICH. 3·10<br>BARKING. 5·00 | 1st Division above Crossness<br>Mean Chlorine in 1st Division (interpolated) 4·05. | 5 miles | 691,088,640 | 0·10 | 691,089 | 99·90 | 690,397,551 | 759,306,240 | 1·90 | 13,117,553 | 1·90 | 0·91 | 2·24 |
| | CROSSNESS. | | | | | | | | | | | | CROSSNESS. |
| ERITH. 83·75 | 1st Division below Crossness<br>Mean Chlorine in 1st Division (interpolated) 83·75. | 5 miles | 1,104,929,660 | 4·10 | 45,302,116 | 95·90 | 1,059,627,544 | 796,709,600 | 3·30 | 34,967,709 | 3·16 | 1·33 | 1·33 |
| | 2nd Division below Crossness<br>Mean Chlorine in 2nd Division (interpolated) 324·0. | 5 miles | 1,528,066,320 | 16·40 | 250,602,876 | 83·60 | 1,277,463,444 | 806,636,960 | 3·20 | 40,878,830 | 2·67 | 1·58 | 2·91 |
| | 3rd Division below Crossness<br>Mean Chlorine in 3rd Division (interpolated) 564·0. | 5 miles | 1,902,671,232 | 28·70 | 546,066,644 | 71·30 | 1,356,604,588 | 806,636,960 | 3·20 | 43,411,347 | 2·28 | 1·68 | 4·59 |
| | 4th Division below Crossness<br>Mean Chlorine in 4th Division (interpolated) 803·0. | 5 miles | 2,706,879,120 | 40·93 | 1,107,113,560 | 59·10 | 1,599,765,560 | 806,636,960 | 3·20 | 51,192,498 | 1·89 | 1·98 | 6·57 |
| | 5th Division below Crossness<br>Mean Chlorine in 5th Division (interpolated) 1163·0. | 5 miles | 3,651,161,680 | 59·30 | 2,165,138,876 | 40·70 | 1,486,022,804 | 806,636,960 | 3·20 | 47,552,730 | 1·30 | 1·84 | 8·41 |
| SOUTHEND. 1522·5 | 6th Division below Crossness<br>Mean Chlorine in 6th Division (interpolated) 1432·0. | 5 miles | 7,695,592,080 | 73·00 | 5,617,782,218 | 27·00 | 2,077,809,862 | 806,636,960 | 3·20 | 66,489,916 | ·86 | 2·58 | 10·99 |
| | SOUTHEND. | | | | | | | | | | | | SOUTHEND. |

* It is assumed for the purpose of calculation, but *not admitted*, that there is no Sewage in the River above Barking.

The *mean* of Columns 13 in the High and Low Water Tables is to be taken as the time of progress towards the sea, on the assumption that the conditions prevailing on the 30th November are maintained during the whole period.
From Teddington to Southend the mean time is 16·59 days. From Crossness to Southend the mean time is 12·78 days.







*M. J. Manergh, M. Inst C.E. F.G.S., F.M.S.*
7 Feb. 1883.

Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.

; Feb. 1883.

"cluding sewage"?—Including sewage when the sewage comes in. I take it that the sewage comes in at Barking.

8692. And it is assumed, for the purpose of calculation, that there is no sewage above Barking. Of course it is not admitted, but you take it so for the purpose of calculation?—Yes, I do not deal with sewage above Barking at all. I disregard it for the purpose of calculation.

8693. (*Sir John Coode.*) You do not admit that there is no sewage above Barking?—I do not admit it, but I disregard it.

8694. (*Professor Williamson.*) You calculate your chlorine upon the assumption that the sewage does go in above Barking?—I have dealt with the chlorine in the sewage when it goes in at Barking, and not above.

8695. (*Mr. Balfour Browne.*) The 6th column shows you, as there is "Nil" in the fourth and fifth columns, that there is a percentage of 100·00 of upland water at Teddington?—Clearly, the difference between column No. 4 and No. 6 is the difference between the 4th column and 100. For instance, 5·40 in the 4th column is opposite 94·60 in the 6th column. Then from that is worked out the quantity of fresh water and sewage in each division. At Southend the fresh water, including sewage, is 4·30, the sea water being 95·70. Then in the next column is the quantity of upland water coming in in each division. You will see the quantity of water coming over Teddington Weir is given at the top of the sheet as 119,990,880 cube feet, but I put it down under the head of "Teddington" at 122,860,800 cube feet, simply because there are tributaries coming in within that first division, and I assume this as all coming in *at* Teddington. I thought it was the simpler plan, so that in the 6th division you get 122,860,800 cube feet per day.

8696. You have passed over the "quantity of upland water and sewage in each division"?—That is got out from the percentages, as in the other case.

8697. I suppose columns No. 5 and No. 7 added together make No. 3?—Yes. Then column No. 8 shows the quantity of upland water at the top of each division, and you will see, when we get down below Crossness, that the Barking contribution of sewage is brought in, and when that is brought in, the chlorine in the upland water is amended by the addition of the 10 parts of chlorine per 100,000 in the sewage. Then the ninth column shows the percentage of sewage in the upland water and sewage; that is to say, the quantity of sewage I have estimated to come in at Barking is 14,760,000 cube feet, which is 10 per cent. of the quantity in the eighth column, opposite "Barking." In the eighth column, the sixth line, the figure you will find is 148,000,000 cube feet, and the sewage coming in at Barking is 14,760,000 cube feet, so that the sewage is practically 10 per cent. of the total; then, as the Crossness sewage comes in, that percentage is increased, and then it is diminished again because there is an addition of clean water coming in from some tributary, and the percentage diminishes from 16 to 15. Then the tenth column would represent the quantity of liquid that has come out of the sewers; that is column 7, multiplied by column 9, and divided by 100. Column 11 shows the percentage of sewage in the whole content of each division; it gives the percentage of sewage in the whole combined body of sea and fresh water. Then the twelfth column gives, in the upper part of it, the progress from Teddington through each of the divisions, and that is obtained by column 7, which is the upland and sewage being divided by column 8, the quantity of water coming in for each division.

8698. (*Mr. Bidder.*) In point of fact, column 13 represents the progress downwards due to displacement only?—No, due to everything; it is due to the sectional area of the river being diminished by the presence of sea water.

8699. If you look at the head of column No. 12, you will find it says, "Time taken to progress through each division, column 7 divided by column 8," therefore it is simply displacement?—Yes, it is displacement, but it is only calculated into that column 7.

8700. It is the rate due to displacement?—But if it were taken into the whole volume, column No. 3, it would increase the number of days immensely. It is all to the good for you.

8701. (*Mr. Abernethy.*) I see that in the second division above Crossness the percentage of sewage is nil?—I do not admit that there is no sewage above, I only assume it for the purpose of these calculations.

(*Mr. Lumley Smith.*) Of course you will not take that as being the fact, it is merely assumed for the purpose of the calculations.

8702. (*Mr. Balfour Browne.*) If it were simply displacement, as my learned friend Mr. Bidder would indicate by his question, you would have divided column 3 by column 9?—Yes, and then the time would have been very much increased.

8703. But as it is displacement and mixing, you divide column 7 by column 8?—Yes.

8704. The result giving you the total progress towards the sea?—The coming in of the sea water tending really to diminish the sectional area, and consequently the content in any division of the river. I divide that by the quantity passing through.

8705. (*Mr. Bidder.*) But this does not take into consideration any acceleration of the downward progress by mixing?—I beg pardon, it does clearly, if you were to deal with the whole content of the river, this number of days would be very largely increased, it is only because I divide column 8, which is the quantity coming in into the diminished content of the river caused by the infusion of the sea water that we get this more rapid rate.

8706. (*Mr. Balfour Browne.*) The twelfth column shows the progress through each division and the thirteenth column shows the total length of time taken?—Yes, and I have divided that into two parts, first of all I give the progress from Teddington to Crossness, time taken 23·98 days, and then from Crossness to Southend 30·73 days.

8707. Every one of the figures you have been giving refers to absolute high water?—They refer to high water upon the 14th of September.

8708. (*Mr. Bidder.*) That column No. 1 which is headed "Chlorine found by analysis," is the actual number of parts of chlorine which the chemist discovered without any inference at all?—Yes. Then, in the second column, there are my interpolations for the mean of the mass in each division.

8709. (*Mr. Balfour Browne.*) That is only a calculation?—Yes, I can show you how I have done it, but I have taken it as fairly as I possibly could.

8710. Now we will pass to low water upon the same date?—With regard to low water upon the same date the table is made out in exactly the same way.

8711. I do not think we need go through all the columns, but let us take one?—I will take column No. 11, on Table M 3b, showing that in the division above Crossness there was 8·70 of sewage in the river, and below Crossness 11·70. Of course by "sewage" I mean what comes out of the sewers. Then at low water the rate of progress from Teddington to Crossness is 10·17 days, and from Crossness to Southend 32·98 days. I had better give you the mean of that. Dealing with Crossness to Southend, which is the important thing, adding high and low water together, and taking the mean, the mean time taken would be 31·85 days. That agrees practically with Mr. Latham's mean, which is 31·34, so that we agree as nearly as can be.

8712. Although you arrive at it from a totally different calculation?—It is a calculation different from the beginning except the chlorine tests.

8713. Have you worked out the mean of those two last columns?—It is not printed here, but I have given my mean of high and low water upon the 14th of September as 31·85 days according to these figures, and 31·34 days according to Mr. Latham's.

8714. The chlorine test was also taken upon another occasion?—I have taken it for the 30th of November.

8715. The table is carried out upon that date in exactly the same way?—Yes, only that we begin with 686,000,000 cube feet coming over Teddington Weir instead of 120,000,000 cube feet. The effect of that very much larger quantity of land water is to increase the rate of progress to the sea and to diminish the quantity of sewage in any section. From Crossness to Southend the mean of high and low water is 12·78 days.

8716. That of course is not upon the tables, but it is the mean between the two tables?—Yes; and the mean which Mr. Latham worked out was 12·65 days.

8717. So that there again you are practically agreed?—Practically, we are; we could not be nearer together.

8718. Have you any remark to make in conclusion upon this part of the case?—The moral to be deduced from that is this, that the thing which keeps the river comparatively clean is a flood such as we had upon the 30th of November. When a big flood comes down it accelerates the progress to the sea very considerably, but the converse of that is true, that whenever there is a very small quantity of water coming down the river in very hot weather, then the number of days will be very largely increased, from 31 up to 50 or 60 possibly.

8719. The chlorine tests are good, but only good for matters that will mix?—They are only good for matters that will mix.

8720. They are not good for solids?—Some of the suspended matter no doubt would partake more of the nature of the movement of the floats.

8721. And therefore, although this does really show what would happen to the fluid sewage, it does not show what would happen to the solid matter?—No, I do not think it does; solids must deposit very largely at the head and tail of the tide.

8722. (*Mr. Abernethy.*) This quantity of sewage relates entirely to what is discharged at Barking and Crossness?—Yes.

8723. And has no relation to what might be disturbed by erosion?—No, the circumstances are taken alike on both days, the 14th and the 30th, as regards the quantity of water coming in and so on.

8724. (*Mr. Balfour Browne.*) The tidal oscillation which is shown by the floats of course makes it inevitable that there is sewage above Barking and Crossness?—Yes, I have no doubt of it at all.

8725. But do you know any method by which the amount of that sewage above Barking could be calculated?—I could not satisfy myself sufficiently, as to the *measurement*, to put it into figures, possibly somebody else might, and therefore I made that note; of course, I know the fact of its being there.

8726. Of course the sewage which you had been dealing with in your tables will not maintain its polluting character and nuisance-creating character all the way down the river?—That is a question which you had better ask the chemists. I have explained to the Commissioners that what I am dealing with is the volume discharged from the outfalls.

8727. So far as you, as an engineer, are concerned, have you anything to say as to what becomes of it?—I am quite certain that a great proportion of the solids sinks to the bottom, and I have something to say as to what becomes of it.

8728. That which sinks or goes down vertically to the bottom gives rise to the nuisance ultimately?—I think it gives rise to the greatest nuisance that ever occurs. I believe that some of the organic matter is deposited—mixing with the ordinary argillaceous matters held in suspension in the river; it goes down with them to form the banks, and then in very hot weather that matter rises and forms the patches of stinking matter which have been described.

8729. Then it is your idea that the banks in these reaches of the river are formed of that combination of argillaceous matter and sewage?—Yes.

8730. Now in the recent Mud Inquiry you plotted a number of cross sections of the river at an equal distance up and down above the Crossness outfall, I think?—Yes. The contention of the Metropolitan Board of Works in that inquiry with regard to the bank in Half-way Reach in front of the southern outfall, was that by dredging operations upon the north side of the river the sectional area had been abnormally increased, and that in consequence there the velocity was diminished, and that the banks were formed in that way. In order to satisfy myself as to whether that was the case or no, I plotted from the middle of Halfway Reach a number of cross sections for 12 miles—that would be six miles above, and six miles below, and then plotting the sectional areas as vertical ordinates, drawing a line from the highest to the lowest, I got what you may call a normal line, and I found that their contention appeared to be a true one—that there was a swelling in the river at that place.

8731. That is to say a swelling in the place where there had been dredging?—Yes, it was called an "aneurism" in the inquiry, there was an aneurism in the river at that spot and we had of course to own it. Perhaps I had better further explain that in getting out these areas I took the areas *without* the mud, because there were originally shoals upon the north side, and when those shoals were removed the contention was that the sectional area had been made too large. Plotting those areas *after* the shoals had been removed, but as if the ***mud had not been deposited***, it showed the aneurism.

8732. The object was to show what was the effect of dredging, and you must leave out the mud for that purpose?—Yes. Then I plotted similar areas with the mud *in* the river and I found that instead of there being an aneurism in the river at that point there was just the other thing, that is say, there was a constriction; the fact was, that the river, instead of being too large, was too small.

(*A drawing was handed in. See Appendix X.*)

8733. Will you just show upon the section both the aneurism that you plotted originally, and the constriction which you find now due to the mud (*the same were pointed out*)?—The longitudinal section was plotted in this way,—The areas of the cross-sections were taken at all the points shown by the vertical lines, and they were plotted from the one horizontal line at the top, so that the ordinates represent the sectional areas. Then the straight line is drawn from the one at six miles above to the one at six miles below, and that line shows that in Halfway Reach just in front of the northern outfall *before* the mud was deposited there was this enlargement. And my point is this, that as the Metropolitan Board of Works pleaded that, and pleaded it successfully, as the cause of the formation of the banks, I have the right to say now that the other thing has occurred, that the deposition of the mud has just caused a contrary effect, it has made the river too small for its work. In 1878 it was too small, and in 1882 it is too small, showing that there is some exceptional cause at work in that place to keep the river small. Either the stuff itself cannot be removed by the currents on account of its own inherent adhesiveness, or, if it is removed, it is immediately replaced. Then I want to add that this mud is caused by a deposition of the ordinary suspended matter of the river, plus the ordinary suspended matter from the sewers, and anything that points to such an accumulation of dirty mud is to the point in this case.

(*Mr. Bidder.*) Perhaps it would be convenient if I were to ask the Commission to consider (of course it is quite competent for you to do so if you think fit), how far you will embark again upon the same identical inquiry, which was the subject of this enormous amount of printed evidence and of the award of the arbitrators. Now what the witness is suggesting, is that the mud banks, which the arbitrators decided upon are the result of the outfalls, that is the very point upon which 1,200 or 1,500 pages of evidence were given in the Mud Inquiry.

*Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.*

7 Feb. 1883.

(*Chairman.*) This point has been raised before, and I think I said, and all my brother Commissioners seemed to be assenting to it, that if it were necessary to go into the inquiry that was raised before those gentlemen, we should be obliged to do it.

(*Mr. Webster.*) The question then was the injury to the navigation, and the award was that there was no injury to the navigation. The question of the deposit of the mud and what it was (being a nuisance as it is in this case), in no way arose in that case.

(*Mr. Bidder.*) I beg my learned friend's pardon. The award of the arbitrators was distinctly upon the question, whether the mud from these banks did or did not come directly from the outfall.

(*Chairman, to Mr. Webster.*) You remind me almost exactly of my own words. I took the trouble previously to look into the award, and I saw what was the bearing of the award, and I saw that it bore simply upon the question of the navigation.

(*Mr. Webster.*) The award said, "Whilst, therefore, "the sewage of the metropolitan outfalls may have "contributed to the offence, the three banks cannot "be said, in the sense of the Act of 1870, to have "arisen from the flow of the sewage."

(*Sir John Coode.*) Moreover, the scope of our inquiry is not limited.

(*Mr. Webster.*) And you would not be bound by that if it were.

(*Sir John Coode.*) We are instructed to inquire whether any evil effects arise from the discharge of the sewage; our inquiry has no special reference to the navigation.

(*Mr. Bidder.*) I began my remarks by saying that obviously Royal Commissioners are not restricted in their inquiry by anything, even by the judgment of a superior court. It strikes me that this inquiry is likely to be a long one anyhow, and one may doubt the limits of human energy when applied even to a Royal Commission.

(*Chairman.*) I said, on a previous occasion, that so far from being a matter of estoppel, I should look upon this Commission, if it went over the same ground, as in the nature of a new trial.

(*Mr. Bidder.*) Of course you can go into it if you desire, but do not labour under the misapprehension which my learned friend is under that the arbitrators in that case confined themselves to finding that these mud banks were not a nuisance to the navigation, because they say:—"We expressly find that" "the "proportion contributed from this latter source is "small as compared with the total amount of sus- "pended matter in the whole volume of tidal water "which flows past the outfalls on every tide."

(*Mr. Webster.*) Then I beg my learned friend's pardon, but I distinctly say we are not going to try the navigation question over again.

(*Chairman.*) At the beginning of the 12th day of our proceedings you will find that the same point was raised.

(*Mr. Abernethy.*) According to my recollection the evidence in that case was confined strictly as to the effect of the banks on the navigation, and not as to their nature in a sanitary point of view.

(*Chairman.*) We think this matter is relevant to the inquiry and that the learned counsel had better proceed.

(*Mr. Bidder.*) Then I may take it that you consider it desirable to go into the whole question of the mud banks again.

(*Chairman.*) All that it is necessary to rule at present is that Mr. Balfour Browne is entitled to put the question he was about to put.

8734. (*Mr. Balfour Browne to the witness.*) Now, with regard to the question I have been asking you about, namely, the constriction, it was not, as I understand you, given in evidence before the arbitrators at all?—No, I had no opportunity of putting in this section. I was allowed to put in the cross sections but I did not put in this one, but I think it is quite pertinent to this inquiry and quite different from what was talked of in the Mud Inquiry.

8735. You have two plottings, one of 1878 and one of 1882—does the 1882 plotting show a considerable increase over that of 1878?—It shows a slight increase.

8736. I understand you to infer that the cause, whatever it is, of these accumulations is going on at present?—No doubt. This show there is some abnormal cause which allows the river to remain constricted at that point.

8737. The ordinary effect of the constriction of the river would be to increase the scour?—Yes, just the converse of the proposition that was put by the other side upon the mud question.

8738. But instead of there being a scour you infer that there is a constant accession of mud or a re-deposit of such an extent that it is replaced after a scour?—Yes.

8739. (*Sir John Coode.*) I see that these observations of 1878 and 1882 extend to about a mile and a quarter over that reach in the river which extends to Halfway House and there is no alteration elsewhere, have you limited your comparison to this mile and a quarter?—I have looked at the sectional areas and I found no increase or decrease of any importance; nothing that would alter this normal line materially; there would be an aneurism in the first case and a constriction in the other.

8740. You tell us that for the six miles above and below there is no material change?—There is no material change for the six miles above and below.

8741. When did you last test them?—By the last surveys from the Thames Conservancy people, within a year or two; what I have shown upon the bank is from the surveys of 1882.

8742. (*Mr. Abernethy.*) That is as far as the section is concerned?—Yes; the bank was about 1,500 yards long, I think, and I wanted to see what the change was upon the bank.

8743. (*Mr. Balfour Browne.*) Is there anything that you desire to add to the evidence which you have given in your examination-in-chief?—No.

Cross-examined by Mr. Bidder.

8744. Just a few preliminary questions upon that matter upon which you have been last asked. The question of whether there is an actual constriction at that point of the river a good deal depends upon whether your blue line, which is taken as what should be, is properly drawn or not?—I did not know how the thing would turn out; for my own information I obtained from the Conservancy Office their surveys, and took a distance of six miles up and six miles down, and plotted the sections, and then drew the line; that is the only way in which I could tell whether the river at this point had changed or not.

8745. I was asking you about the blue line. If, instead of taking the starting point of your blue line, as you have, you had taken, for instance, Margaretness Bank, 7 W upon your section and 11 E upon your section, and joined those two points together, would you not have had a very much larger difference?—It would have been an aneurism from end to end in that case. I took a length which I thought was a fair length, a length which I thought would give me a reliable basis to work upon.

8746. I am not suggesting that the points I have indicated are the proper points to take, but, in point of fact, the question of what is aneurism and what is constriction depends upon the question of where you select your points. I could draw a line which would put quite a good face upon it?—The way in which the points were selected was this; I took the middle of Half Way Reach, which represents the middle of the bank opposite the southern outfall, and I said I would take an equal length of section upon each side,

and I took the nearest section to that length that I could get from the surveys, but I could not tell whether it would be larger or smaller relatively.

8747. You chose to take six miles upon each side?—I thought 12 miles was a sufficient length of the river to give me the information I wanted, and I found that it proved your case, and I admitted it at once.

8748. Going upon that principle; taking, as you say, the middle of Half Way Reach; if, instead of taking six miles, you had taken five miles upon each side, you would have got a very different result, would you not?—It would have shown an aneurism without the mud and a constriction with the mud.

8749. If you had gone five miles upon each side, will you just show the Commissioners what your line would have been then?—I can see, without drawing a line, that there would have been an aneurism for you and a constriction for me.

8750. The blue line would have been pushed up a good deal?—I should have had to admit that you were right in that case, and I should have contended that you were wrong now. I knew nothing about it when I took these sections.

8751. I do not suggest for a minute that you selected particular points that would suit your purpose, for, as you say very fairly, you selected without any particular reason six miles upon each side?—Yes.

8752. And it is a matter of chance, you say, whether you happened to select five, six, or seven miles which showed a result one way or the other?—I think, if you were to take five miles upon each side, though the line would not be in the same place, the result would be the same.

8753. Just lay down upon the section before the Commissioners the blue line, taking five miles upon each side.

(*Chairman.*) We should be very glad to see how any alteration of the line would affect that bank if it exists.

(*Mr. Bidder.*) It just depends upon how you take the points of departure, whether it is an aneurism or constriction. (*The witness measured the distance upon the plan.*)

(*Witness.*) I have taken it a mile nearer upon each side, and it results in practically the same thing.

(*Sir John Coode to Mr. Bidder.*) If the tinted portion of the section is right, representing the ordinates, and the line is drawn there correctly, the changing of the line will not make any difference as regards the question of accumulation; it will as regards an average line; it has merely an effect just like raising or lowering the datum line of the section.

(*Mr. Bidder.*) But the witness's evidence is that, taking the contour of the river now as it is with the mud, there is, instead of an aneurism, a constriction, and by a constriction he means a sectional area less than the normal. Now, according as you shift the blue line, you shift the normal.

(*Witness.*) It is very little altered really.

(*Sir John Coode.*) At the same time it does not alter the fact of there being an accumulation there. As regards the constriction or aneurism, it does.

(*Mr. Bidder.*) Everybody knew there was an accumulation at that point on the last occasion, and everybody knows it now. You need not trouble your mind about whether there is an accumulation of mud there or not; there is, and we know it; and the question was as to the cause of the accumulation, as Mr. Mansergh has pointed out to-day. True, there is an accumulation, and we say that by dredging at that point of the river the sectional area was increased and turned into an aneurism, but Mr. Mansergh now says, "When I plot the river with the mud in, "instead of there being an aneurism, there is a "constriction."

(*Chairman.*) The witness says, "When I was "called as a witness on another inquiry, I had this "put before me, and I admitted, upon the facts "represented upon this plan, that there was an "aneurism; but, looking into the matter as I have "now done, and taking these data, and making the "necessary enquiry, I find that instead of there "being an aneurism there is a constriction."

(*Witness.*) That was not exactly so. I had done all this before, but it was not allowed to come out in the evidence for some reason or another.

8754. (*Mr. Webster.*) Did you make two sets of observations, one for the other inquiry and one for this?—The point I want to make is this, that there is a special cause keeping the bank there, and that that special cause is the sewage discharge; that with the sewage discharge organic matter is carried down with the other mud, and that that organic matter in hot weather becomes a nuisance.

8755. (*Mr. Bidder.*) When you say a special cause is keeping the mud there, you found that upon the fact, which you say your diagram shows, that there is a constriction at that point?—Yes.

8756. And that there is a constriction at that point you infer because the sectional area at that point is less than the normal area at that point?—Yes.

8757. Which normal sectional area is defined by the position of the blue line?—Yes.

8758. And it depends upon the position of the blue line whether the sectional area is greater or less than the normal?—Yes.

8759. It does come to that. The position of the blue line is at the root of the whole of the evidence?—Yes; but I have told the Commission how I obtained the blue line. I did it for my own information simply. When I found it told against me, I admitted it frankly, and now, when I find it tells in my favour, I am entitled to use it.

8760. You admitted upon the previous inquiry that undoubtedly the dredging operations of the Conservators had had a considerable effect in bringing the deposit to this spot?—Yes, I said so then, and I say so now.

8761. You have examined the other parts of the river above and below, and you found nothing of the kind?—No.

8762. You only point to a constriction below Crossness?—I was only trying to find out what was happening there.

8763. Did you look at the other parts?—I have looked generally at the sectional areas above and below.

8764. And you found no constriction?—There is, I should say, a constriction at Margaretness Bank and at Barking Bank; but about that Mr. More can tell you better than I can.

8765. But upon the last inquiry you did not confine yourself to that one bank, you gave evidence as to all three. How is it that you are now confining yourself to this point?—Because I am not bound to ramble all over the river. When I find a good point at Half Way Reach, I am entitled to make use of it. Mr. More can tell you what is going on at Margaretness and Barking.

8766. Your section shows several large white constrictions; are those the natural bed of the river?—Those are just worked out from the surveys of the Conservators as I found them.

8767. I see no evidence of any constriction at Erith Reach and Erith Rands. As far as I gather, in Erith Reach the sectional area is fully up to the normal?—It is just about the normal according to this test.

8768. Now I should like to understand, if I can, some of these tables of yours. That table M. 3*a*, and those in the same bundle, I suppose, are upon the same principle?—Yes.

8769. In the first table you have given the parts of chlorine per 100,000 derived from the chemist's analyses?—Yes.

8770. The "percentage of sea water (from chlorine)" and the "percentage of upland water, including sewage," as I understand, are derived in the way that Mr. Baldwin Latham explained?—Yes.

8771. I suppose you would admit that its accuracy depends upon the assumption which he took, and which I see you adopt at the head of the table, that

*Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.*

7 Feb. 1883.

sewage contains 10 parts of chlorine and the sea water 1,961, and that, if those are wrong, the tables are wrong?—Yes; but in the parts below Crossness, to which I have directed the table, it would have very little effect indeed; so little, that it would not have any effect worth naming. I do not suppose it would have the effect of a tenth of a day upon the progress out of the river.

8772. Just take the fifth division above Crossness—this seems to be rather a fine matter—it is an inference upon an inference. You say the mean chlorine in that case is 4·7; then I see you say the percentage of sea water is 0·2?—Yes, that is taking into account the 1·7, the initial quantity.

8773. I will take that as an illustration. Sea water contains 1961 parts in the 100,000?—Yes.

8774. So that one per cent. of sea water would contain 19·61?—Yes.

8775. And one-fifth, or 0·2 per cent., would contain just under 4 grains, 3·9; is that right, 3·9 parts?—Yes.

8776. If I take that away from the 4·7, that leaves me 0·8 of a part?—Yes.

8777. How can that possibly be. I do not follow that, because that makes out that all the rest is only 0·8 parts in 100,000, whereas the river water contains more than that, and sewage still more?—Sea water is taken at 19·61, and, adopting Mr. Latham's formula, the result is 99·8 per cent. of upland water. Taking the 99·8 per cent. from the 100, you get the 0·2.

8778. You have only allowed the river water and sewage combined one-half the percentage of chlorine that there is in pure river water. There must be something fallacious in the whole business, because one-fifth of a part of sea-water has 3·9 grains, and that only leaves 0·8 of a part in 100,000 for the 99 parts remaining?—But where do you get the one-fifth of a part of sea-water?

8779. Percentage of sea-water 0·2; that is one-fifth of one per cent.?—That is 1–500th.

8780. That is 3·9 parts in 100,000 parts; that only leaves 0·8 parts for the rest; whereas, if it were pure river water alone, it ought to contain more than that?—You do not make it clear to me.

(*Mr. Lumley Smith.*) The 4·7 you are applying it to is the average figure, but it is not 4·7 at that particular point.

8781. (*Dr. Stevenson.*) In column 4 you have only taken the first place in decimals, have you? You have not gone to the second place in decimals?—It works out to 99·84 in salt water.

(*Mr. Webster.*) What Mr. Bidder has taken is 4·7 as the average figure, but if an average figure is taken, it must be something very different from 4·7.

(*Witness.*) The Chiswick sample was taken as the mean of the whole mass of five miles.

(*Chairman.*) The 0·2 does not mean the chlorine.

8782. (*Mr. Bidder.*) It means the percentage of sea-water derived by inference from the chlorine. (*To the witness.*) What I am wanting to do is to understand how this table is made up; how do you get at that?—I dealt with it by a formula similar to Mr. Latham's; A minus B divided by A minus C. A is the sea-water, 1961, and C is the chlorine in the sample found, 4·7.

8783. What does B represent?—The river water. A minus B divided by A minus C equals the percentage of land water. (*The witness exhibited his calculation.*) You get 99·8 as the amount of land water, and, taking that from the 100, you get 0·2.

8784. That is upon the assumption that the water is pure river at that point?—Yes.

8785. You assume there is no sewage there?—Yes; I do not take sewage into account till you get to Crossness.

8786. What do you do with the sewage at Richmond and Hampton?—All the analyses show that the water at Teddington contains 1·7.

8787. But Richmond is below Teddington?—I have only taken the chlorine as shown by the chemists.

(*Mr. Webster.*) It assumes it being all sea water except the 1·7.

8788. (*Mr. Abernethy.*) You have not dealt with the sewage question at all in this column?—Not there. I have taken the chlorine as it exists, whether it comes from the sewage or whether it comes from the sea.

8789. (*Mr. Bidder.*) Now, I want to make another thing clear; for instance, supposing, as I suggested to Mr. Baldwin Latham, that the sewage contains, not 10 parts of chlorine, but 20?—That would make a correction.

8790. That would reduce the sectional areas due to your sewage and water?—Yes.

8791. And accelerate your period of driving seaward?—No. I attach very little importance to it down to Crossness, and below Crossness it would make a little difference in diminishing the rate of progress.

8792. I see that from Crossness to Southend, upon that particular day you have taken, that 14th of September, the high-water figures would give you a period of 31 days to get to the sea. I suppose we may call Southend practically getting to sea?—Yes.

8793. The low-water figures would give you 33 days getting to sea?—Yes; but you must take the mean of that; you cannot compare them.

8794. That was taken at a time when the water coming over Teddington weir was exceptionally low?—Not exceptionally low.

(*Mr. Bidder.*) If you will look at Mr. Baldwin Latham's Report on page 49, where he tables the number of feet coming over the weir at Teddington, he gives the quantity on September the 14th as being only 83,327 cube feet a minute (I think I am more right than I thought I was), whereas he admitted to me that 150,000 was the average, so that it is about half the average.

8795. (*Mr. Webster.*) According to the Mud Inquiry the average water over Teddington Weir was found to be 133,000,000 cube feet in the 24 hours, and the minimum 57,000,000 cube feet?—According to this the average would be 110,000. Taking 3,676 square miles of drainage area, and taking the mean flow as 30 cube feet a minute, it is a little below the mean, but not very much.

8796. The other observation which you give, of the 30th of November, makes the rate of progress according to the high water figure of getting to Southend 14½ days, and according to the low water figure, 11 days?—Yes.

8797. How do you explain it, that whereas in the first case the low water figures give a longer period than the high water figures, in the second case they give a shorter period?—You must take the means. I do not profess that these tables of high and low water separately can be taken as representing the progress, you must take the means, it does seem a litle anomalous, but I think there is an explanation to it.

8798. The mean, taking the 30th of November figures, would be 13 days?—Yes.

8799. Therefore taking the results of these tables I might say the average maximum progress of the sewage derived from this cause would be something between 13 and 31 days?—No, the 30th of November is an exceptional time.

8800. One is something below the average, and the other is something above it, so I take it the mean would be between 13 and 31 days. If one is below the average and the other is above the average, the mean must be somewhere between them?—Yes, but, as I pointed out before, on neither of those occasions probably would there be a nuisance in the river, neither upon the 14th of September nor upon the 30th of November.

8801. But I want to get exactly at what the tables tell us?—They tell us the facts with regard to those days.

8802. Do the tables take into account the way in which the progress to sea would be accelerated by mixing with the sea water?—Oh yes, clearly.

8803. Just let me put a question to you which arises from the first table you put in. Your Table

M 1 shows roughly this, does it not, that the tidal section between Barking and Southend, is 18,000,000,000 cube feet at low water, and about double that at high water, is not that so?—Very nearly so.

8804. So that I may say that, on any given ebb of the water that was contained between Barking and Southend at high water, half of it has gone to sea at low water?—But then the same water comes back again.

8805. At any rate half of it has gone to sea at low water?—It has not gone to sea, it has gone a certain distance down the river.

8806. When I say "gone to sea" I mean gone past Southend?—But you must not understand that the whole of that dark blue strip has progressed out of the river, part of it has gone down.

8807. Between Barking and Southend at high-water there are about 36,000,000,000 cube feet of water, and at low-water only 18,000,000,000 cube feet?—Yes.

8808. And half of it has gone seaward of Southend?—Half of the whole *quantity*, but certainly not *that* dark blue water.

(*Mr. Abernethy.*) Not that particular tide water.

(*Prof. Williamson.*) That might all have gone and some other have taken its place.

8809. (*Mr. Bidder.*) If I take a pot with two quarts in it at 12 o'clock, and at 6 o'clock find there is only one quart in it, that shows that one quart must have gone somewhere, so that half the water between Barking and Southend has gone from between those points, it has gone somewhere?—Half that quantity has gone seaward, but it has gone from the extreme high-water line to the bottom of the river for a short length above Southend.

*Mr. J. Mansergh, M. Inst. C.E., F.G.S., F.M.S.*

7 Feb. 1883.

8810. Half of the whole of the water that is between Barking and Southend at high-water has gone to sea at low-water?—Yes.

8811. Without doubt?—Yes.

8812. And therefore, assuming that there may be 5 or 20 days sewage in the water between Barking and Southend, half of that has gone to sea?—But then it comes back to-morrow.

8813. It goes into the tides along the coast, does it not?—No, it goes 12 or 13 miles along the coast and comes back again.

8814. By what elective affinity can you show that, when that water has got to sea, it will, like salmon, come back to the river where it was bred?—But you will see that Southend is many miles short of the mouth of the river.

*Mr. Webster* stated that he feared Mr. Mansergh's engagements would not permit of his being present at the next week's sittings of the Commission, in which event he would be prepared to interpolate other evidence.

Adjourned to Tuesday next, at half past 12 o'clock.

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# TWENTY-FIRST DAY.

## Tuesday, 13th February 1883.

PRESENT:

THE RIGHT HONOURABLE LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR P. BENSON MAXWELL.
SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANCOIS DE CHAUMONT, ESQ., M.D., F.R.S
THOS. STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary.*

MR. JAMES MANSERGH, Mem. Inst., C.E., called again.

(*Mr. Balfour Browne.*) Before my learned friend continues his cross-examination, I think it well to state that Mr. Mansergh has plotted on paper now what Sir John Coode asked for upon one occasion, and perhaps it is only fair that it should be put in before my learned friend, Mr. Bidder, resumes his cross-examination. One of the members of the Commission upon the last occasion asked Mr. Mansergh if he had taken the sections of the river above and below the outfall, as well as at the outfall, where he showed the aneurism. Mr. Mansergh has since that time taken the section both above and below, and will show the Commission the result of his survey. It was an aneurism, as the Commission will remember long ago, but now it has been turned into a constriction, according to Mr. Mansergh, by reason of the deposit of mud.

13 Feb. 1883.

*See Appendix X.*

8815. (*Mr. Balfour Browne to the Witness.*) You have also, I think, a line showing the high water up and down the river?—I have. These (*producing the Diagrams: See Appendix Y.*) are sections of the river upon the days of the tides which I named, plotted to the scale which the Commissioner asked for, namely, four miles to the inch horizontal, and eight feet to an inch vertical; those represent the synchronous lines of high-water, low water, mean flood, and mean ebb at Southend. These show the same thing at Barking (*pointing to the diagram*). The same was explained to the Commission.

*Further cross-examined by Mr. Bidder.*

8816. Just a question or two upon these diagrams that you put in this morning. I asked you last time, and you admitted to me that this blue line is what you may call to a certain extent an arbitrary line, that is to say, the starting points are selected arbitrarily, and that if the starting points had been selected differently the height would have been different?—No doubt. I explained how I selected it.

8817. No doubt you are aware, as an engineer, that that blue line is intended to represent what should be the normal river?—Taking the two ends as being normal points.

8818. Then you have drawn it as a straight line?—Yes.

8819. Are you aware that in theory, to make it perfectly correct it should not be a straight line?—I do not know how I should draw it differently.

8820. If the blue line is to represent a sectional

*Mr. J. Mansergh, M. Inst. C.E.*

18 Feb. 1883.

area proportionate to the water above it, it should be a curved line and not a straight line?—But it would be such a flat curve that you could not show it upon a thing of that sort.

8821. Surely?—No, you could not.

8822. I have drawn your attention to it, and that is enough. Now you said upon the last occasion that, upon the former inquiry, when the question of whether the banks were caused by the sewers or not was the subject of inquiry, you were not allowed to put the section in. Now I have been looking at the evidence and I cannot find that; therefore I must ask you, was there any objection taken upon the part of the Metropolitan Board of Works or the arbitrators to your putting in any section you liked?—Not at all. I did not say that the objection proceeded either from the Metropolitan Board of Works or the arbitrators.

8823. I am sure you would not mis-state a thing, but it appears from the notes as if the Metropolitan Board of Works or the arbitrator, had objected to it?—No, it does not read upon the notes like anything of the kind.

8824. You simply mean there, that your counsel did not think it expedient to bring it forward?—Yes, probably that was so; possibly I was not pertinacious enough about it.

8825. Now, I leave that, and I have one or two questions more to ask you with regard to the subject upon which I broke off when we were here last. This table of yours, M 3a., from which mainly your deductions are made, purports to show the condition of the river at high water and at low water upon two different days, the first being the 14th September and the second the 30th of November, and it purports to show also, first, the cubic content of the river in each division; I see that you have divided it into five mile lengths?—I have divided it into five mile lengths, except the one at Teddington.

8826. Then it purports to show the percentage of sea water, quantity of sea water, percentage of upland water, including sewage, and the number of day the sewage takes to travel down to different points?—Yes.

8827. I want to make it quite certain, and to understand the principles upon which these tables have been founded. First, as regards the cubic content of the river in each division, that of course is a mere question of measurement?—That is the measurement from the cross section.

8828. Now, as regards the rest, as I understand, the actual facts from which you have constructed this table, are these. First, that at certain points in the river on the occasion referred to, the chemists took samples of the water and ascertained how many parts of chlorine there were in 100,000 parts?—Yes.

8829. And from those observations you deduced the proportion of sea water in that part of the river?—Yes.

8830. I am anxious that his Lordship should follow this, because it is at the root of the whole table. (*To the witness.*) At the head of your table you say that pure sea water, you assume, contains 1961 parts of chlorine in the 100,000 parts?—Yes.

8831. The sewage and upland water in both cases contain compared with that, an infinitesimal quantity?—Yes, upland water 1·7 and sewage 10.

8832. So that you may put it that supposing, as in this table, you find in the first division below Crossness that there are actually 1031 parts of chloirne in 100,000 parts you ask yourself the question, how many parts of sea water must there be, and how many parts of fresh water, without any chorine to make up that mixture?—Yes.

8833. That is a mere question of mixture?—Yes.

8834. From that you deduce the column No. 4, which is the percentage of sea water?—Yes.

8835. And of course the complement of that, to make up the 100 in column 6 which is the percentage of upland water and sewage?—Yes.

8836. Now in order to make that estimate of how much of that column 6, percentage is upland water, and how much is sewage, you make an assumption that the upland water and sewage are in the proportion that the quantity of water, that you gauged coming over Teddingtom Weir and other tributaries during that day bears to the quantity of sewage that you know the Metropolitan Board of Works have sent out?—Yes.

8837. So that I have accurately stated the basis of the table?—Yes.

8838. Will you turn now, if you please, to the 30th of November, the same principle applies to all these tables?—Yes.

8839. Taking the 30th of November, at high water, the lowest division, the sixth division, below Crossness, you there deduce in that way, that 86 per cent of the water in that division at high water is sea water?—Yes.

8840. And 14 per cent. the other water?—Yes, 13·70 per cent.

8841. And you have got that, assuming that the sea water contains 1961 parts of chlorine?—Yes.

8842. Of course that sea water comes from below Southend?—Yes.

8843. Do not your own analysis there, and the chemists analysis upon which you based it, show that upon that day the sea water below Southend did not contain 1961 parts of chlorine, but only contained 1785 parts of chlorine? I draw your attention to the table which Mr. Baldwin Latham put in to page 4 of the analysis of Professor Way. Now in the last pair of columns there is given the chlorine upon this very day, and I may in point of fact say that those are the very analyses upon which your table is based?—The analysis my table is based upon is this (*producing a paper*).

8844. Is that the same as Professor Way's, to which I am drawing your attention?—Yes.

8845. Now look at the 30th day of November, and you will see that Professor Way shows that at high water at Southend, the water contained 1785 parts, and at low water, 1522 parts, and that even at Margate, which is 30 miles away to sea, at high water it contained 1770, and at low water 1735; at Margate, as we know, the estuary is 30 miles broad, does not it follow from that table that the water which came up from the sea to Southend and filled the river at high water was not water containing 1961 parts, but water containing 1774 parts?—Yes, because upon that day, and for some time before that day, a large quantity of fresh water had gone down the river.

8846. But your table was based upon the assumption that water came in from the sea as, if I may use the phrase, "standardly" pure sea water, whereas the analysis show that out in the estuary 30 miles in width the water was of a much lower standard?—If that is the assumption——

(*Mr. Webster.*) But it is not the fact (as we have given evidence) that the water at Margate is pure sea water, it is in fact very much diluted, we do not admit that the water at Margate is pure sea water, or anything like it.

(*Mr Bidder.*) I was drawing the witness's attention to this fact, that the water of the estuary below Southend down to Margate, was not water containing 1961 parts of chlorine but was water containing something over 1700, say 1750, taking the mean at Margate.

(*Witness.*) All it shows to me is this, that a large quantity of land water has come down the river, and even as far as Margate, is diluting the sea water.

8847. Will you just turn your eyes to the map. Margate, as we know, is at the very point of the North Foreland, is it not, or close to it?—Yes.

8848. And the estuary there is about 30 miles broad, as nearly as I can recollect?—Yes.

8849. Whatever may be the cause you may say the upland water or anything else. I do not know what the cause is, you do not suggest to the Commission that the sea at Margate is composed of fresh water?—I do indeed; I say that the fresh water which comes down the Thames had that effect upon the sea

water at Margate upon that day. If you take Southend you will see——

8850. I would rather keep to Margate, if you do not mind. Therefore I am not wrong in saying that if your assumption is right the figure represents that about 12 per cent. of the sea at Margate is fresh water?—I dare say it is; it would work out to that.

8851. But am I not right in suggesting that that would be more fresh water than the river would produce in a year?—Yes, but you must not take it all over the river; that might be due to the currents along the shore.

(*Chairman.*) If I understand it rightly, it is three times the percentage of fresh water at Southend.

(*Mr. Bidder.*) It is three times what it was at Southend on the 14th September.

(*Chairman.*) Upon the Table M. 3a, you state the percentage of upland water and sewage as 4·30 at Southend, but it can hardly have been more salt there than it was at Margate.

(*Mr. Webster.*) Is your lordship comparing the particulars of the same day?

(*Witness.*) We have no Margate samples upon the 14th and 22nd of September, but if you compare the great difference there is from Southend upon the same day, you will find my statement borne out.

8852. (*Mr. Bidder.*) I do not know where you got your figure of 1961, as representing pure sea water from?—That is a chemist's business, I got it from the chemists.

8853. You may be aware as a matter of fact that it is a matter of general observation that the amount of salt in the English Channel, is considerably less than the standard of pure sea water?—I do not know that. I had that from the chemists.

8854. Now comparing the 30th of November, high water with low, I put it to you upon the last occasion and you substantially admitted it. I am right in saying, am I not, that substantially the content of the river at high water between Southend and Teddington is twice what it is at low water?—That is so.

8855. And half the water in the river therefore it follows at any particular high water goes out seaward of Southend during the ensuing ebb?—Yes.

8856. And is replaced at the next flood by substantially an equal quantity of salt water coming from the estuary?—Yes, but the 18,000,000,000 or the 19,000,000,000 you are talking of represent only about eight or nine miles at the low end. If you will take one of the blue sections, say a spring tide section, although the dark blue, which represents the quantity coming in during the flood tides amounts to 18 millions in the length from Barking to Southend, that whole strip does not go out because that quantity is contained in the eight miles at the bottom end immediately above Southend.

8857. Have I ever said that it goes out in that ridiculous way; all I put to you, and what I want to get broadly clear is, that half the quantity has gone. I do not say that it comes out n that ridiculous strip?—You may say that piece (*pointing to the plan*) has gone out of the river. The water from the dark blue follows down to fill the low water section below.

8858. I will still deal with your table; for instance, upon the 14th of September, taking the high water figures, the whole of the sixth division below Crossness with its 14,430,000,000 has gone to sea?—The whole of that quantity has gone to sea, and some of the next division.

8859. About two-thirds of the next division?—Yes, about three miles of the next division.

8860. And with it has gone to sea the 93,000,000 of sewage that was in it, and two-thirds of the 136,000,000 that was in the next division?—Yes, out of that low bit; but the water in the dark blue, the high water part, simply goes into the low water section.

8861. At the ensuing high water, a similar quantity of water comes up from below Southend?—Yes, from below Southend.

8862. And you will not suggest to the Commission that it is the identical water that went out?—No, of course I cannot suggest that it is the identical water that went out; so long as it is within the river, it has oscillated up and down to a certain extent, but that it is the identical water, drop for drop, no one, of course, could say.

8863. In point of fact then, it amounts to this, does it not, that in a tide about seven days' sewage is swept out to sea, according to your figures, if your table is right.

(*Chairman.*) Every tide?

8964. (*Mr. Bidder.*) I have not added what is coming next; this is if Mr. Mansergh's table is correct—I am going to say that it is entirely wrong (*to the witness.*) If your table is correct, several days' sewage is swept to sea every tide; you may say that some of it comes back, if you like, by the next tide?—26,000,000 I take as the sewage.

8865. If you look at your table, the whole of the last section which contains 93,000,000 of sewage has gone to sea, and two-thirds of the next section, which is about 90,000,000 of sewage, that is 183,000,000, which is equal to seven days' supply?—Yes, but it comes back again.

8866. You may say that if you like, I am only establishing the deduction from your tables, if your tables are correct that seven days' sewage is swept into the estuary every tide?—Swept below Southend.

8867. Do you suggest that the whole of that comes back every tide?—Some proportion of it.

8868. Having regard to the fact that it is mixed up by the tides and currents and the eddies and the estuaries, what proportion would you say comes back, roughly speaking?—You can only deal with it by taking, as we have taken it, the chlorine and estimating the quantity of sea water in it.

8869. Your chlorine test, assuming it is rightly applied, only shows that a certain percentage of water in that part of the river is not sea water?—It shows that it is not sea water.

8870. It does not show that it is water that comes down the Thames, or that it is water that comes down the sewers?—It must come either one way or the other.

8871. I will show you another place that it might have come from, it might have come from the Medway, might it not?—We take the end of the river as being at Southend, so as to avoid any complication with the Medway.

8872. The Medway pours its water into the estuary of the river a little below that point, does it not?—Yes.

8873. And that water comes back with the tide?—Yes; we can only get at it by the chlorine.

8874. Therefore a proportion, I will not undertake to say what proportion, of this water which is brought in by the tide is Medway water, and not Thames river water at all?—It is so.

8875. And your inference that because there is so much fresh water, there is therefore that proportion of sewage in it, would fall to the ground?—Yes; but in dealing with this lower division; it is a matter of very little importance, we know that at Southend very little injury is done by the sewage, but taking it at Barking and Crossness, where you are not complicated with the Medway water, you cannot contend that the Medway water comes up that 30 miles; I do not say that any nuisance arises at Southend.

8876. But the same principle applies all over your table?—But you cannot get water from the Medway up as far as Crossness in a tide.

8877. Why not?—Because the tidal oscillation would be 30 miles.

8878. The water below Southend is weaker than sea water, because it is mixed with fresh water?—Yes.

8879. And that mixture arises partly from the water of the Medway?—Yes.

8880. The water which comes from below Southend is the only water from which you could account for any excess of chlorine at Westminster?—Yes.

*Mr. J. Mansergh, M. Inst. C.E.*

13 Feb. 1883.

8881. Therefore, you may reasonably infer that where you find in the channel of the Thames any excess of chlorine, you must have some of the Medway water?—Yes, no doubt. It would be of import just at the mouth of the Medway, and in that direction, but higher up it is of very little import.

8882. Running into the Thames, besides the Medway, there is the Blackwater.

(*Chairman.*) And the Colne.

(*Mr. Balfour Browne.*) All those are included in the table.

8883. (*Mr. Bidder.*) I think the Blackwater is not included in the table, because if you look at column 8, showing the quantity of upland water, you will see that it never increases below Crossness?—All I say is, that we have taken all the water coming into the river above Southend.

8884. But your own chemists' analysis have established that this dilution extends to Margate; now do you happen to know, as regards the Medway, what is the average amount of drainage?—No, I do not know anything about it.

8885. Your table shows, and I mention it, because Mr. Balfour Browne interpolated a remark about these being all included, that you have included nothing that comes into the Thames below Erith?—I told you that the tributaries were so small that I had put them all in at the top of the second division below Crossness.

(*Chairman.*) There are considerable floods in the Medway above Maidstone in very bad weather such as this, but in ordinary weather very little water comes down.

(*Witness, to Mr. Bidder.*) You will see that I put in all the tributaries at the head of the second division; it is all to your good as far as progress is concerned.

8886. (*Mr. Bidder.*) One thing catches my eye on looking at the table; if you look at the 10th column, there is another curious result in the table, that in the third division below Crossness you seem to have actually less sewage than in the one below that?—Yes, that is deduced from the figures.

8887. Do you believe that?—Yes, I do.

8888. Less than the one above it, and less than the one below it?—Yes; I am only basing it upon the chlorine and the contents.

8889. Do you believe it is true, as a matter of fact?—I believe the contents are correct.

8890. How do you account for it?—I do not attempt to account for it at all. I have taken 1502 as the chlorine at Gravesend. I know the contents are right, and all the other figures are simply worked out from them. It seems to be an anomaly, but there it is, I cannot account for it as a fact.

8891. Of course your table does not pretend to take any account of the extent to which the sewage has been destroyed by decomposition?—No.

8892. It is a table that assumes that if a gallon of sewage is put into the river at Barking or Crossness, it will remain a gallon of sewage until the end of time?—In quantity. I simply stated when I described the table that it represented the quantity which came down through the sewers.

8893. A gallon of sewage put into the river at Barking or Crossness, according to the figures in your table, is a gallon of sewage, though it may have been down to the estuary, and may have, in fact, returned after many months?—That is what it means.

8894. Your own experience tells you, does it not, that in practice, sewage put into a large volume of running water is very rapidly burnt up?—I think I must leave the chemists to deal with that question.

8895. I have had the pleasure of examining you very frequently upon sanitary matters, and water questions, and I ask you to give the Committee the benefit of your experience and opinion. Is it not the result of your experience, that sewage put into running water is very rapidly annihilated and destroyed by chemical decomposition?—I think it is destroyed to some extent, but I do not know how far.

8896. Does not your experience lead you to believe that that applies to a very great extent?—When men like Dr. Frankland and Dr. Tidy, and other gentlemen of their eminence disagree, I had rather leave it to them; it is a question for the chemists.

8897. But you have not been afraid to give your opinion upon other occasions, do not let any new accession of modesty prevent you from doing it upon this occasion?—I would much prefer leaving it to the chemists.

8898. Is it not your belief that running water, to a great extent, purifies sewage and destroys it?—I think it does to some extent; but I think also that a good deal of the solid matter is deposited in the bed of the river.

8899. Of the matter in suspension?—Yes.

8900. Now I must ask you upon that, this question as that is coming back to the mud banks. As you referred in your evidence upon the last occasion, and as you pointedly refer to the mud banks now, let me ask you, do you agree with me as to one paragraph on page 26 of the report of the arbitrators upon that inquiry "That each of the three banks," one of them is the very bank you have been drawing attention to this morning, "has arisen from the dredging operations in Barking and Halfway Reaches carried on by the Conservators of the Thames, or sanctioned by them; such dredging operations having removed material, and having increased the sectional area, of the river, and altered the direction of the flow of the currents and tide, so as to produce a diminished velocity in those parts of the Reaches where the banks are situated, thereby causing a deposition of matter suspended in the river and the formation of the three banks"?—Yes.

8901. Do you agree with that?—I do; but I also want to emphasize the other point; that now there is no increase of the sectional area, there is just the other thing, there is a diminution of the sectional area, and therefore an increase of the velocity.

8902. Let me put this to you, when you say there is a diminution of the sectional area, is not the sectional area at that point now greater than it was before the Conservators began their dredging operations, still making allowance for all the mud bank which is found there?—I do not think I can give you the figures now, but I should say not, certainly.

8903. Do not say so unless you have ground for it, for I have very strong ground for holding the opposite opinion?—I believe the 1861 area is here somewhere.

8904. You have given us a certain amount of sectional areas of the river upon the paper M 2; but you have cross sections of the river all the way down, have you not?—I had 134 plotted.

8905. Have you objection to producing them all?—I do not think so; my cross sections, as I explained, are between something above high water and something below low water. The sectional areas below low water, that is below 7·50 under ordnance datum, are from Mr. More, excepting where the mean area sections are given, and those I have calculated.

8906. There seems to be some errors in this table of yours?—Which is that.

8907. Table M 2; they may be serious or they may not, but I will show you. Opposite Deptford you will see the low water area upon the 14th of September is 12,927 square feet, then referring to the 30th of November it is 12,900 square feet, which is rather less; but, if you look at the point to which the tides ascend in a few days, it was lower water upon the 14th of September than it was upon the 30th of November, so that with a larger depth of water you have a less sectional area?—But it was a deal higher at Teddington.

8908. Never mind Teddington, let Teddington take care of itself?—You must draw a line between the two.

8909. Does not table M 2 purport to give the sectional area of the river at high water and low water at particular places?—Yes.

8910. Then I draw your attention to this, that at Deptford you represent the sectional area, to be

greater upon the 14th of September than it was upon the 30th of November, although the water itself had sunk to a lower level?—Where do you say it was lower.

8911. O.D. minus 7·50, is not that the tide?—Yes, that is lower.

8912. The next is O.D. minus 7·40?—But that is at the 74th section, that is miles below Deptford, and you must get the mean level by drawing a line between the two.

8913. You will correct me if I am wrong, but I am told that these figures must have been taken from the tide gauge at Deptford?—I am positive about all these areas. I have checked them and cross checked them in every possible way, and I can satisfy Mr. Law that that is right.

8914. You stated that you agreed with the finding of the arbitrators with regard to the banks, but you said that the suspended matter came from the sewers; now I will ask you if you agree with the next paragraph that "the water in the tidal portion of the "Thames contains a considerable amount of suspended "matter derived partly from the basin of the Thames "and its tributaries, partly from the washing away of "the foreshores of the tidal estuary, where unpro-"tected, partly from material brought up from the "mouth of the river by the flood tide, partly from "sand and mud stirred up in the course of dredging "operations, partly from denudation of the river bed, "partly from sewers in districts outside the Metro-"politan area, and partly from the sewers of the "Metropolitan Board. The proportion contributed "from this latter source is small as compared with "the total amount of suspended matter in the whole "volume of tidal water which flows past the outfalls "on every tide"?—That may be so.

8915. Then we go on a step further—"That the "three banks are composed of matter which has been "held in suspension in the water, and had been "derived from the several sources above mentioned. "Whilst, therefore, the sewage from the Metropolitan "outfalls may have contributed to their contents the "three banks cannot be said, in the sense of the Act "of 1870, to have arisen from the flow of sewage at "the outfalls"?—I do not object to this judgment, but still I say, as the arbitrators say here, that a part of the banks is formed from the discharge of the sewers; that is all I want to say now.

8916. Now we will leave the mere words and follow the substantial reasoning. The banks formed at that place because the velocity of the water had been diminished?—Yes.

8917. And the comparative stagnation or reduction of the velocity caused the matter in supension in the water to fall to the bottom?—Yes.

8918. Whatever matter happened to be in suspension at the time, provided it was not too light, would go to the bottom and help to form the bank?—Yes.

8919. And of that matter, which in point of fact is matter in suspension in a gallon of Thames water, a very small proportion indeed has anything to do with the sewers of the Metropolitan Board of Works?—A small proportion, yes.

8920. Therefore, as regards any bank which is formed in that way, a very small proportion at the best can be traced to the sewers as its origin?—Yes; but that is the portion which creates the nuisance in hot weather.

8921. Now you are riding your other horse?—I must ride my other horse.

8922. Of course you may say that a grain of prussic acid may be much more serious than an ounce of salts but we are upon the question of whether a bank is composed of sewage or not?—But I say that the river is too small—you made it out too large before, and I say fairly made it out too large; but now it is too small, and that shows that there is some abnormal cause at work. To state it more fully, the contention of the Metropolitan Board of Works originally was that on account of dredging operations in the Dagenham shoals, the river had been made too large opposite the southern outfall, consequently the velocity was reduced, and any suspended matter in the river was deposited. Now, I say, since the discharge has gone on for 15 or 20 years, the river has been actually made too small at that place, therefore the velocity has increased, and yet it is not sufficient of itself to remove the banks which are formed, showing that there is some abnormal cause at work—either that the material discharged is of an unusually adhesive character, or that it is immediately replaced when the bed has been scoured.

8923. But when you say that the river is too small, I venture to challenge you as to whether the sectional area of the river is not now larger, with all the mud in it, than it was when the Commissioners began dredging?—My opinion is, though I have not the sections here, that you will find the river is smaller.

8924. Your own Table M 2, shows that instead of there being a constriction at that point, there is, on the contrary, a very great enlargement. Look at high water upon the 14th of September: the first that comes, or I will take, as being better, the sectional areas at mean tide level. At Barking you give the sectional area at just a little under 44,000 feet, but when you come to Crossness, which is only a mile and a half below it, you show the sectional area to be increased to 50,200?—Yes, that may be the mean side sectional area, but I give you the low water areas plotted upon that diagram, which will show that upon the whole there is a constriction.

8925. Now going back for a moment to Table M 3a, the quantities of sewage which are shown in the table represent by sewage the general liquid which comes out of the sewers of the Metropolitan Board of Works?—Yes, that is what I have said.

8926. But of that, of course, only a very small proportion indeed would be what would be called sewage proper?—We call sewage proper everything that has gone through the house, the fouled water supply.

8927. But it may be water that has gone from the roofs and the gutters?—Yes, it would include that.

8928. But the mere excreta would be a very small proportion of the whole?—I am not going down to excreta. I am speaking of the 30 gallons a head upon the north side.

8929. But the foul element of the sewage is a very minute percentage, something like half per cent, is it not?—I do not know about the quantities; the quantity I am talking about is the fouled water supply, what we know technically as sewage.

*Re-examined by Mr. Webster.*

8930. I will take first the question which has been put to you last of all; is it the fact that the limit of one-half per cent of excreta would be the sole polluting element in the sewage?—Certainly not.

8931. There would be kitchen water, and all kinds of things that would increase the polluting element?—Yes.

8932. I understand you to say, whatever the result, that you have dealt with the quantity which is supposed to be poured out at Barking and Crossness?—Yes, that is so.

8933. It is clear from your own sections and plans, that opposite Southend, and for two or three miles above, the estuary expands considerably?—Yes.

8934. And of course the cross section increases considerably?—Yes, it does.

8935. In order to ascertain what is the real result of washing backwards and forwards in the River Thames itself, do you think that the lower reaches are as important as, we will say, the 15 miles below Crossness?—No, certainly not.

(*Chairman*). Is the witness an expert upon the point?

(*Mr. Webster.*) I think so, my Lord. I am not

*Mr. J. Mansergh, M. Inst. C.E.*

13 Feb. 1883.

suggesting that he can tell your Lordship exactly; but my learned friend, Mr. Bidder, has put to him in cross-examination that in the lower section the whole of it would be washed out, and I merely wish to get his opinion that the upper reaches are more important than the reaches nearer the sea.

(*Chairman.*) I thought my brother Commissioners were as capable of judging the value of the different reaches of the Thames as Mr. Mansergh.

(*Mr Webster.*) I quite agree with that; but sometimes counsel does not want to take the whole responsibility of leaving a matter without questions being asked upon it.

8936. (*To the witness.*) Two matters were pointed out the other day, to which I should now refer. When you worked out the percentage of chlorine in sewage, it was suggested that your percentage was wrong?—Yes, it was.

8937. I believe you have again checked your formula?—I have.

8938. Will you state now how you carried out the calculation?—Dealing, as I was, broadly with the question, interpolating mean chlorine for a large mass of water (five miles in length of the river), it would have been undue refinement to go to several places of decimals with the percentages. By leaving the figures as in the table, there appears to be an error, but this is not so if they are carried further, thus,—

$$\frac{1961-4\cdot7}{1961-1\cdot7}=\frac{1956\cdot3}{1959\cdot3}=\cdot9984688,$$

which is the proportion of upland water. Multiplying this by 1·7, the chlorine in upland waters, we get $\cdot9984688\times1\cdot7=1\cdot6973969$. Then deducting the ·9984688 from 1· we get ·0015312, which multiplied by 1961, the chlorine in sea water, gives 3·0026832, and this added to the 1·6973969 makes a total of 4·7000801, which is the exact figure given in the 1st column of the table.

8939. In the column below Crossness it made no difference at all?—No difference at all; and it would have absolutely checked if it had been carried sufficiently far.

8940. Is it the fact, as far as you can judge, that there is a difference between the sea water at Margate as compared with the sea water at Southend. I will read the figures off to you from the tables; it is 1785 at Southend and 1770 for Margate upon the 30th of November at high water, and at low water at Southend it is 1522 against 1735 at Margate?—Yes.

8941. Therefore, upon the only day that we can compare, there is at high water a little more chlorine at Southend, and at low water considerably less than there is at Margate?—Yes.

(*Chairman.*) You think it may be more salt at Southend than at Margate, or as salt, at all events.

(*Mr. Webster.*) As salt.

(*Chairman.*) I do not see the impossibility of it, because the tide in the channel fills in from the north, and it may be that the rivers that flow into the German Ocean are not so considerable in proportion to the volume of water they meet there.

(*Mr. Webster.*) We should not be surprised at any result; but what I wish to point out as far as your Lordship has it now before you, is that upon the day that we compare it, the water is as near as possible substantially the same; it is 1,785 as against 1,770, a difference of 15 parts only at high water, and at low water it is 1,522 as against 1,735, or a difference of just over 200 parts, so that there is not the marked difference which your Lordship pointed out, taking another day's table, when you put it at four times the proportion.

8942. (*To the witness.*) You have said over and over again that the quantities of chlorine you have taken from the chemist without altering them at all, and you have made your deductions from them, assuming them to be facts?—Yes.

8943. I think this is clear. My learned friend, Mr. Bidder, suggested to you that you had assumed that a gallon of sewage remains a gallon of sewage for the purpose of all the calculations. Is it the fact that any gallon of water in the river below the outfall may be made up of water which has gone out to sea, and of water that has come back again?—Yes.

8944. And may be a mixture of any number of gallons which have previously come from the river itself?—Yes.

*Mr. Bidder* objected.

(*Mr. Webster.*) We are working back from a given state of chlorine, and the deductions may be wrong, but we do not assume any quantity of sewage except what is shown by the deductions from the chlorine.

8945. (*To the witness.*) Now you have said fairly enough, as I think, that the float experiments cannot be relied upon for actual calculation, but only show the range of the floating up and down of a certain part of the water?—That is so.

8946. Do you think, given that range of the tide, that any great volume of the Medway water, as fresh water, can get up the river?—It cannot get very far up the river.

8947. About 12 miles, as we know, is the extreme range of any tide?—Yes.

8948. Therefore it must be very largely diluted at any point above Southend?—Yes, certainly.

8949. I ought to say that it is not the fact that the Blackwater goes into the estuary, that is the River Crouch at Maldon, and not the Blackwater. (*To the witness.*) My learned friend, Mr. Bidder, puts it to you, that it is possible (and you have not yet checked his figures) that where that bank is the river may be in fact larger than it was before the dredging operations of the Thames Conservancy took place?—Yes.

8950. At present you have not your figures to check that?—I have figures with regard to the year 1861, but I have not them here.

8951. Taking your section, showing what it does now, if they are facts, and comparing what the state of things was at the time of the Sewage Inquiry with what it is now, do you or do you not consider that there is a constriction in the river there?—I do.

8952. Having regard to the section of the river below it and the section above it?—Yes.

8953. And if the reasoning as to the increase of velocity is sound, that ought to induce a less deposit instead of a greater deposit?—Certainly; the increased velocity ought to remove the bank.

8954. (*Chairman.*) But there is a diminished velocity above the constriction?—No doubt, relatively, in the constricted section the velocity ought to be increased; if it is increased, it ought to scour away the banks, but it does not scour away the banks.

8955. (*Mr. Webster.*) Or, if it does, it re-deposits almost immediately?—It does.

8956. (*Chairman.*) If you refer to table M 3a, upon the lowest line but one, I see 6,000,000,000 cubic feet of water, with a percentage of 12½ of upland water?—The 6,372,982,770 is the quantity of sea water in that division.

8957. And there is a percentage of 12·50 of upland water?—Yes, 910,000,000.

8958. In the division below that, there are 13,800,000,000, with a percentage of 4·30, and only 620,000,000 of upland water—what has become of the rest of the upland water?—This table really represents the quantity of upland water out of the whole volume of water in the river at that place.

8959. But I want to know what has become of it, if the total volume of water is double, that is to say, if the content of the river is double, one would suppose it would have at least half the percentage of upland water that the single quantity had?—Yes, but these percentages are of the two divisions of the river at the same time; the 5th division contains only half the total quantity.

(*Chairman.*) Then there is nothing in my question.

(*Mr. Bidder.*) I venture to think that there is something in your Lorship's question, because what is to-day the water in the 6th division would be in two or three days the water in the 5th division.

(*Chairman.*) I understood you to say that the coming in of the salt water had driven back the fresh water.

(*Witness.*) It merely follows from the two facts that we have to go on, the content of the section and the chlorine found.

8960. (*Mr. Balfour Browne.*) Has the mixing any bearing upon it?—The mixing is shown by the chlorine.

*Mr. J. Mansergh, M. Inst. C.E.*

13 Feb. 1883.

The witness withdrew.

Mr. Charles James More, Mem. Inst. C.E., examined.

*Mr. C. J. More, M. Inst. C.E.*

8961. (*Mr. Lumley Smith.*) I believe you are engineer to the Conservators of the River Thames?—I am.

8962. You have been so, and have been constantly upon the river, have you not, between London and Gravesend for the last 13 years?—I have, as engineer and assistant engineer.

8963. Do you go over other parts of the river?—I go in all parts of the river.

8964. Have you personally surveyed the river at the lower part below London Bridge?—I have as far as the lower end of Long Reach.

8965. Are you acquainted with the nature of the bed throughout the whole of that district?—I am at one period or another, and quite recently with the part which is near the outfall.

8966. To begin with the terminus *ad quem*, going upwards from Long Reach, how far does your personal knowledge of the bed extend?—Up to the pool, close to London Bridge.

8967. In various places you find accumulations of mud, do you not?—Yes.

8968. Is that uniformly deposited over the bed, or is it found in places?—It is found in parts almost entirely across the bed; at other parts it is simply in bights. I have before me three plans which show exactly the present condition of the bed of the river, which I wish to place before the Commission; they show the deposit of mud, gravel, clay, and peat.

(*The same were handed in. See Appendices* Z 1, 2, 3).

8969. (*Chairman.*) When you speak of the mud, did you go down merely to the surface?—The mud is of all depths, it is from 6 or 7 inches to 8 or 10 feet depth. I merely show the surface of it.

8970. Would you say that the mud was a part of the natural bed of the river, or something that has been brought there from time to time?—It is evident that that has been brought there, because the natural bed of the river was gravel originally; how it was brought there, is the question.

8971. (*Mr. Lumley Smith.*) Let me take you through the different reaches; first of all, will you allow me to direct you to Bugsby's Reach; in Bugsby's Reach what do you find?—In Bugsby's Reach there is not much deposit of mud until you get down to the lower end of it, except upon the foreshore, that is between high and low-water mark.

8972. Is that on both sides?—That is on both sides, and that would vary very much according to the season and the amount of rainfall; in the higher reaches of the river especially it varies with the rainfall.

8973. Now, we will take Woolwich Reach?—Woolwich Reach is a very muddy reach indeed; there is a very large deposit of mud in Woolwich Reach, extending almost across the river.

8974. Is that subject to variation?—Yes, the depth of that would vary a foot or two feet at times.

8975. Does that vary according to the season of the year or year by year?—Year by year, the surveys show a difference in the depth of water from one to two feet.

8976. Now, Galleon's Reach, what do you find there?—Galleon's Reach, upon the Essex side, is very muddy indeed; all along the bight it is. Up near the Beckton Gas Works there is a great depth of mud.

8977. And upon that reach is situated the Barking outfall, is it not?—At the lower end of that reach.

8978. Does the mud extend to there?—Yes, the mud extends as far as Barking Creek, all round the lower end of the bight.

8979. Is it of any depth?—Yes, it is 6 or 8 feet deep.

8980. Now the next is Barking Reach, what is the state of that?—Barking Reach is very muddy from Margaretness on the north side to Crossness upon the south side, and from False Point as far as opposite Dagenham, upon the north side.

8981. Does that extend across the river, or is that upon the side?—It extends very nearly across at one point.

8982. Does that vary at all?—Slightly, near the lower end of the reach it varies.

8983. Again, when you speak of it varying does that vary at different times of the year or in different years?—It is rather in different years, because we do not survey it every year. In the different surveys we find that there is a different depth.

8984. What is the condition of Halfway Reach?—Halfway Reach is extremely muddy, especially all along the south side where the southern outfalls are.

8985. (*Sir John Coode.*) What depth of mud should you say there is there?—It is 9 or 10 feet far out into the river, and that mud is extending gradually down to the lower end of the reach.

8986. It is extending further down the reach?—It is extending further down the reach.

8987. Upon the south side?—Yes, upon the south side, and it is extending further out into the centre of the river.

8988. How often do you test it?—We have occasionally soundings taken here and there every year, but regular surveys throughout the whole reach every two or three years; we used to have them every year.

8989. What do you find upon the north side?—There is also mud off the north side opposite Jenningtree point.

8990. (*Mr. Lumley Smith.*) The next reach is Erith Reach?—Yes, from Jenningtree point down to Erith, all down the Kentish side of the river, is muddy; there is a great quantity of mud and of great depth towards the lower end of the reach.

*Sir John Coode* (*to Mr. Webster.*) Are you going to give the Commission any evidence as to the character of the mud.

(*Mr. Webster.*) Yes.

8991. (*Mr. Lumley Smith.*) At the lower end you come to the town of Erith?—Yes.

8992. What do you find there; is there any mud?—There is a very great deposit, 6 or 7 feet deep.

8993. To what distance does that extend into the river?—It goes about a third of the way across there.

8994. Has that varied at all?—It has rather increased lately—the latest soundings show rather more mud there than there had been before.

8995. And now we come to Erith Rands?—There is not much mud round Erith Rands, until you come to Crayfordness, and then down Long Reach you find mud in the very centre of the river.

8996. Below that point, you have no knowledge from actual surveys?—No, I have not.

8997. Does your observation enable you to speak of what there is between high and low water mark?—Between high and low water-mark there is a great deal of mud all the way down past Gravesend.

8998. Is that mud found in places which you have known for some years?—I know places which I can remember quite clean, or at all events so that you could land from a boat without difficulty, where you have now 3 or 4 feet of mud.

*Mr. C. J. More, M. Inst. C.E.*

13 Feb. 1883.

8999. Are you able to tell us in a general way, or in more detail, where the chief changes have been—does the mud shift much from time to time?—No I do not think it does, it keeps pretty much in the same places; the depth may slightly vary, but the locality is pretty much the same.

9000. It is not that you find one place clean that was muddy before, but practically it remains pretty much in the same place?—Yes, except that it extends in area year by year.

9001. Are you able to specify any particular parts in which the increase has taken place since you have known the river?—It has increased mostly in the neighbourhood of the outfall in Barking and Halfway Reaches.

9002. I do not know whether you are able to tell us anything of the character of the mud?—I can only tell you that it is a very black slimy sort of a mud. I know nothing about it chemically.

9003. Do you know the mud which is found higher up or lower down the river, some considerable distance from the outfalls—is it the same class as that, or not?—It is blacker, and of a more offensive character near the outfalls than elsewhere in the reaches; it is very much complained of by the men who are engaged by the Conservators to raise anchor, and wrecks; they complain of the offensive character of the mud which comes up in those reaches.

9004. (*Chairman.*) Do you know the character of the Medway mud?—No.

9005. (*Mr. Lumley Smith.*) Now you use the expression "in those reaches"—what reaches are you speaking of?—All the way down the river, even down to Sea Reach, I am told that mud of this description covers the articles which they bring up.

9006. Is that of more recent origin?—I do not know of my own knowledge, but they tell me that it did not use to be so.

9007. (*Sir John Coode.*) What is the date of any survey you have before the opening of the outfalls?—The only survey we had then is that of 1861, which began above the northern outfall and extended down the river.

9008. Could you show the Commission any chart showing the area of the mud in 1861, to compare with the one you have now put in?—I cannot, because upon that chart they have not indicated each sounding—they have simply put an occasional "G" for gravel and sometimes an "M" for mud.

9009. The notes with regard to the bottom were only occasional?—The notes with regard to the bottom were only occasional.

9010. (*Mr. Lumley Smith.*) From your own observation, are you able to speak to the offensive character of the mud?—Yes, I have noticed it frequently in the summer time; there is a most offensive smell in these reaches from the water; there is no doubt about that.

9011. When you say "these reaches," which do you mean?—I have smelt it even at Woolwich when I have been waiting for my boat, when it has been stirred up by a steamboat, and there has been a horrible smell, but in the winter there is no smell, except just by the outfall.

9012. Then it is the increase of the temperature in the summer months which makes it offensive?—Yes.

9013. Have you seen sewage going up stream at all?—I have seen sewage running out from the northern outfall up to low water—in a small stream, not in any quantity.

9014. Would that be frequently the case or not?—Yes.

9015. Whatever got out there would be of course carried up by the flood?—It would go up at once.

9016. Are there any other nuisances or matters of an offensive character that you could tell us of which you have seen with regard to these outfalls?—No, I think not, beyond what I have said already.

9017. You have prepared sections, have you not, of the bed of the river; are those what you have been showing to the Commission?—It is not a section, it is simply a plan of the bed.

9018. What years are they for?—One of them, the Barking and Halfway Reach, is for 1882, the others are for 1877, 1878, and 1879, the latest surveys that we have.

9019. Have you prepared any sections for previous years?—Not in the neighbourhood of the outfalls.

9020. Now, have you prepared sections at Erith Rands?—I have sections; we were asked for all sections of the river. Captain Burstal produced a section of a portion of the river, and I have prepared a section right across the river.

(*The same were handed in. See Appendix* A A.)

9021. As I understand, Captain Burstal had produced a section which showed a change upon the south side?—Yes.

9022. And my learned friend, Mr. Bidder, wished to have the section plotted throughout, so as to show what change had taken place throughout?—Yes.

9023. You have produced those sections; now, for what years are they?—They are for the years 1832, 1861, and 1882.

9024. What alterations, speaking generally, do they show at Erith Reach and the Rands?—They show a good deal of dredging between the years 1832 and 1861.

9025. That would be before the opening of the outfalls?—Yes, before the opening of the outfalls.

9026 Do they show any accumulation of mud in 1882 since 1832 upon the south side?—Yes a very large accumulation.

9027. When has it taken place, between 1832 and 1861, or between 1861 and 1882?—Between 1861 and 1882, most of it.

9028. And when was the dredging principally done?—The greater part of the dredging was done between 1832 and 1861; at some part of that period, but I do not know exactly what part of that period.

9029. Now, did you take any part in the float experiments which have been brought before the Commissioners?—I did not take any part in those experiments.

9030. But you are familiar with the run of the tide in the different reaches, are you not?—Yes, I have taken float observations in the reaches near the outfalls some time ago.

9031. Were they taken in the same way, with the same class of float as has been used upon this occasion?—They were not taken for the same purpose as the float observations were taken upon this inquiry; they were taken for the purpose of observing the set of the currents, and not for the purpose of observing the distance an object would float with the tides.

9032. When you come to the crooked parts of the river above Long Reach, do you find that the flow of the stream is variable there, or equal all the way up?—It is very variable indeed.

9033. More so than in the lower reaches?—Yes, much more so.

9034. What is the difference—are there eddies?—There are eddies of different velocity round the points and upon different sides of the reaches, and at different points of the reaches.

9035. May I take it that objects in the reaches would be more subject to the influence arising from the shape of the reaches than objects outside the reaches?—Yes.

9036. Would that account for two floats that are in the same reach, making different journies?—Yes; it would depend entirely upon the particular stream they got into; if one got into an eddy, it would remain there for some considerable time.

(*Mr. Bidder.*) I would suggest, after what Mr. Mansergh said, whether it is worth while following the floats any further. Mr. Mansergh said that they showed how the water oscillated up and down, but not how the whole body of the water moved.

(*Chairman.*) I was going to say that the experiment

shows a result which is a perfectly honest one, but it also shows a result which is a fallacious one.

(*Mr. Lumley Smith.*) It does not, of course, show that the main body of water will always move as a particular float did.

(*Mr. Bidder.*) There is no dispute between us that the water in the Thames, be it sewage or ordinary water, does not go straight away to sea, but oscillates up and down much as the floats might have done; but as both the witnesses have admitted that the floats are no guide as to the way in which the water or sewage reaches the sea, I think we had better bury them.

(*Chairman.*) Can they mend your admission of half a mile a day?

(*Mr. Bidder.*) They make it rather more.

(*Mr Lumley Smith.*) The floats, to a certain extent, show what the condition of the sewage would be in the river; that a portion of it oscillates up and down. They do not prove the extent to which each day the sewage gets out to sea, but they do show what happens to the sewage when it gets into the river.

(*Mr. Bidder.*) If my learned friend is going to rely upon their showing anything more than that the water of the river oscillates up and down, I shall be obliged to go into it, because I shall be in a position to show that it depended very much upon the number of public houses upon the banks how far they made progress in any particular direction.

At this point Sir P. Benson Maxwell took the chair.

Cross-examined by Mr. Bidder.

9037. Now you are the engineer to the Thames Conservators?—I am.

9038. Therefore I am right in saying that you gave all this evidence, and, perhaps, I might add a little more, upon the last inquiry?—Yes, I did.

9039. And you put in practically the same sections and pointed out the same mud banks?—Very much so.

9040. And you asked the arbitrators upon that inquiry to draw the same conclusion that the mud came from the sewers?—I believe they were asked to do that.

9041. Now with reference to the Erith Bank, about which you have handed in sections to-day, and which I have in my hand, just tell me this, as I have been looking at the sections, do they not show that between 1861 and 1882 there had been principally upon the north side of the river at that point, very considerable excavations and deepening of the river?—Yes, there had been, undoubtedly, upon the two lower sections.

9042. So that contemporaneously with the growth of the mud bank upon the south side of the river there had been deepening by dredging operations upon the north side?—There had been dredging undoubtedly.

9043. Exactly the same process has been going on, as we showed had been going on with regard to the three banks above upon the last inquiry?—Yes, the dredging had been going on during that time.

9044. I think you admitted upon the last inquiry, and you will admit again, that at each of those points, at Barking, Margaretness, and Halfway Reach, it was true that mud banks had been growing, but it was equally true that contemporaneously with the growth of the mud banks there had been enormous dredging operations carried on by the Conservators of the Thames upon the opposite side of the river?—There had been dredging operations carried on, not by the Conservators, but by other people.

9045. Under their sanction at all events?—Yes.

9046. As the result of the river being deepened artificially on the one side, and silting up naturally on the other, the sectional area was increased?—Yes; but it was not upon one side alone that the dredging took place.

9047. Still the result was on the whole that the sectional area was increased?—The sectional area was increased, there is no doubt about that.

9048. And you adhere to that still?—Yes.

9049. Now you said just now that the river was offensive in the summer, I should like to ask you, at what part of the river you say that there is any apparent offensiveness?—Woolwich Reach is a very offensive place in hot weather, and from there down to Erith Reach.

9050. That, you say, you observe when steamers stir up the mud?—Undoubtedly, when a steamer, our steamer, for instance, stirs up the mud with her paddles, the effluvium is extremely offensive.

Re-examined by Mr. Lumley Smith.

9051. My learned friend asked you some questions with regard to the sectional area being increased; dredging had taken place, you said, opposite Erith Rands?—I was speaking of the part opposite the southern outfall.

9052. When you said the sectional area was increased, what period were you speaking of then?—It must have been going on for some time. I think the first attempt to do anything there was in 1863, very little was done then, and then after that, whether it was 1866 or 1867, I do not remember the dates exactly, but off and on for several years, there was a good deal of dredging done there; it was the removal of the shoal which was called the Dagenham Shoal.

9053. There is an accumulation of mud upon the opposite side?—A very large accumulation indeed.

9054. Has that accumulation of mud more than counterbalanced the increase of the sectional area, which was due to the dredging; are you speaking of what was due to the dredging without taking into account what was added by the mud?—Yes, if you dredge you must increase the sectional area.

9055. (*Mr. Abernethy.*) Has there been any dredging upon the northern side, opposite the southern outfall?—No, not since the date of the last inquiry, I should say, and the accumulation is still going on.

9056. You do not say the sectional area had increased, having regard to the deposit of mud?—No, I say if you dredge, the sectional area must be increased.

(*Mr. Bidder.*) My question to the witness was directly with regard to this point. Whether comparing the river now with what it was before the silting began, the sectional area had increased, and he says—"undoubtedly, if you dredge you increase the sectional area."

(*Mr. Abernethy.*) Where has the dredging taken place in recent years.

(*Witness.*) In recent years it has taken place mostly in Erith Reach.

9057. And there has been no dredging opposite the Crossness outfall for three years past?—No, not in that particular part. I think it was before 1879 that the dredging was done there.

9058. (*Mr. Bidder.*) In this part of the river, where you say mud is deposited, comparing the sectional area of the river with the dredging and with the mud as it exists, with the sectional area of the river before the mud and before the dredging, is not the sectional area greater now than it was before?—Compared with what—the year 1861, do you mean?

9059. Take the sectional area of the river as it is now dredged in part and with the mud, comparing it with what it was in 1861 before the dredging and before the mud, is it not greater now than it was then?—I cannot answer that question right off. I could give you the actual areas, but I cannot answer

*Mr. C. J. More, M. Inst. C.E.*

13 Feb. 1883.

that comparative question. I understood your question to be, whether the sectional area had not been increased, and that therefore the mud came there in consequence.

9060. (*Chairman, Sir Benson Maxwell.*) Mr. Bidder understood that plan of yours to show that there had been an increase?—I can give you the exact figures, but I have not them with me at the moment.

(*Mr. Bidder.*) I wish you to understand that I am taking the river as it is dredged in part and with the mud silted up.

9061. (*Mr. Abernethy to the witness.*) You gave your answer to Mr. Bidder with regard to a certain section of the river?—Yes, opposite the outfall.

9062. Then your answer was not a general answer with regard to the river generally?—No, it related to that particular part.

(*Mr. Bidder.*) My question was a general question with regard to all the reaches of the river that the witness has particularised.

(*Chairman.*) I understood you to refer to that particular one.

(*Mr. Bidder.*) No, I put it with regard to all the reaches, Erith Reach, Barking Reach, and Halfway Reach; whether it was not in every case true that the sectional area was largely increased.

(*Witness.*) I must have time to look the matter up before I answer the question.

9063. (*Mr. Lumley Smith.*) Then apart from the fact that the dredging, for the time being, increased the sectional area, you cannot tell us for the moment what the change has been?—No, I cannot.

9064. Of course we may take it that the accumulation of mud has diminished the sectional area?—Yes certainly.

The witness withdrew.

Mr. James Mansergh recalled and further examined.

*Mr. J. Mansergh.*

(*Witness.*) Mr. Bidder asked me if I knew whether the areas in Halfway Reach in 1882 were larger or smaller than they were in 1861, and I said that I had not the figures with me at the time, but now I have them; this was with regard to the constriction that was alleged. I have it with regard to eight sections, and I will hand in that table (*having measured*), they extend over a mile and an eighth of the river, between 5 W. and 2 E. I will give you first the cross-sectional areas in 1861, cross-section 5 W.

9065. (*Sir John Coode.*) That is, according to your section, about 1,400 yards above zero; but that is not opposite the southern outfall?—It is in Halfway Reach, in the middle of the bank.

9066. We will take it as being measured from the southern outfall; 5 W. is about 900 yards above the southern outfall, and 2 E is about 1,100 yards below the southern outfalls?—Yes, that is so. If you will allow me to give the sections at the same time, as they are printed in the Mud Case book they can be referred to; it is at page 616; in 1861 the 5 W. section had an area of 29,866; and in 1882 it had an area of 28,419 square feet; so that now it is a little smaller there. In 1861, the 4 W. section had an area of 31,386 square feet, and in 1882 it had an area of 31,297 square feet, so that that is a little smaller now. The 3 W. section had an area in 1861 of 33,529 square feet, and in 1882 it had an area of 32,845 square feet; that is also smaller. In 1861 the 2 W. section had an area of 31,427 square feet, it has now an area of 32,439 square feet; that is now a little larger. The 1 W. section had in 1861 an area of 27,586 square feet; it has now an area of 28,397; that again is a little larger. The zero section had in 1861 an area of 28,140 square feet, it has now an area of 28,094 square feet; that is a little smaller, practically it is identical. The 1 E. section in 1861 had an area of 32,369 square feet, it has now an area of 29,488 square feet; that is smaller. The 2 E. section had an area in 1861, of 33,278 square feet, while in 1882 the area was 30,958; that is also smaller.

9067. (*Mr. Lumley Smith.*) The one where you said there was a considerable reduction is a little lower than the outfall?—A little lower down.

9068. (*Mr. Bidder.*) The figures of 1882 are, of course, new figures, introduced since the last Inquiry; but at what time of the year were these figures taken?—Mr. More can tell you better than I can; it was in 1882.

9069. You know that in any particular mud bank the sectional area varies at different times of the year, according as there is more or less flood water?—No doubt.

9070. You may get a sectional area at one time of the year which will differ from that at another time of the year?—You asked me the question; I did not volunteer the information.

9071. What are the bases of your 1861 section?—The Conservators Surveys of the 1861.

9072. I cannot quite follow it; you said when you put them in before, in answer to the question put by Captain Galton, "Those are the sections in 1861?" —Yes; the same numbers apply"; then at question 6802 you are asked "The composite section is the one "upon which the hydraulic mean depth is worked "out," and your answer was "Yes"?—The 1861 sections I now refer to are the sections of the river before the Dagenham Shoals were removed, and of course before the mud was deposited.

9073. And I daresay you will tell me this as you told me at question 6815 in the Mud Inquiry, when I said "tell me frankly now what it will show; it is useful "for the arbitrators to know" and you said "It "shows that the river was made a little large in the "Crossness Bank," there is no doubt that the river was made too big at that point by dredging?—No doubt, but it has grown up since.

9074. (*Mr. Lumley Smith.*) This year 1882 has been a very wet year?—Yes.

9075. Would that tend by the increase of the flood water to increase the sectional area?—No doubt it would tend to increase the sectional area, but I cannot tell at what time these sections were taken.

The witness withdrew.

Mr. Charles James More recalled and further examined.

*Mr. C. J. More, M. Inst. C.E.*

9076. (*Mr. Lumley Smith.*) Could you now answer the question which Mr. Mansergh could not as to the time of year when these cross-sections were taken?—Those would be taken about September of last year.

9077. That was a time when the flood water came down?—There was a good deal of rain over the whole of the year—it was a wet summer. I did not take them myself.

9078. (*Sir John Coode.*) According to the diagram put in, the quantity of water coming over Teddington Weir in the month of September was very small; it was a very dry month—the water did not begin to rise until the middle of October?—The survey began about the beginning of August and they got down to Erith, and it was such bad weather that they could not get on with it, and they did not finish until November.

9079. (*Mr. Lumley Smith.*) When they got below the outfall did the bad weather come on?—I could not speak to that myself.

(*Sir John Coode.*) The diagram which has been put in will show us exactly the quantity of water going over Teddington Weir day by day.

9079*a*. (*Mr. Lumley Smith.*) You stated that you were able to give us some figures—will you now do so?—These (*producing some tables*) are the areas of the cross-sections I put in a little while ago.

(*The same were handed in, and are as follows.*)

Areas of Cross Sections of the River Thames.

(ERITH.)

| Section. | 1832 S. feet. | 1861 S. feet. | 1882 S. feet. |
|---|---|---|---|
| 725 feet above beacon at low water | 35,343·20 | 46,072·80 | 42,829·80 |
| (Erith) „ mean - | 59,140·70 | 70,535·30 | 67,054·80 |
| „ T. H. W. | 87,705·70 | 99,532·80 | 95,992·30 |
| 75 feet above beacon „ low water | 35,261·05 | 47,326·55 | 44,762·85 |
| (Erith) „ mean - | 59,201·05 | 71,808·05 | 68,892·85 |
| „ T. H. W. | 87,613·55 | 100,478·05 | 97,808·05 |
| 280 feet above Sand Wharf - - „ low water | 36,377·55 | 44,963·80 | 44,708·90 |
| (Erith) „ mean - | 59,605·05 | 69,017·80 | 67,907·90 |
| „ T. H. W. | 88,072·55 | 97,855·30 | 96,557·90 |
| At Erith Town Causeway - - „ low water | 33,090·15 | 40,578·90 | 42,822·50 |
| „ mean - | 56,460·15 | 64,110·40 | 65,575·00 |
| „ T. H. W. | 85,031·40 | 92,721·65 | 94,127·50 |

Increase and Decrease in area of Cross Sections.

(ERITH.)

| Section. | | | | Sectional areas. Increase. | Sectional areas. Decrease. |
|---|---|---|---|---|---|
| 725 feet above beacon - | at low water | from 1832 to 1861 | | 10,729·60 | |
| | „ | „ 1861 „ 1882 | | | 3,243·00 |
| | „ mean | „ 1832 „ 1861 | | 11,394·60 | |
| | „ | „ 1861 „ 1882 | | | 34,840·50 |
| | „ T. H. W. | „ 1832 „ 1861 | | 11,827·10 | |
| | „ | „ 1861 „ 1882 | | | 3,540·50 |
| 75 feet above beacon - | „ low water | „ 1832 „ 1861 | | 12,065·50 | |
| | „ | „ 1861 „ 1882 | | | 2,563·70 |
| | „ mean | „ 1832 „ 1861 | | 12,607·00 | |
| | „ | „ 1861 „ 1882 | | | 2,915·20 |
| | „ T. H. W. | „ 1832 „ 1861 | | 12,864·50 | |
| | „ | „ 1861 „ 1882 | | | 2,670·00 |
| 280 feet above Sand Wharf - | „ low water | „ 1832 „ 1861 | | 8,586·25 | |
| | „ | „ 1861 „ 1882 | | | 254·90 |
| | „ mean | „ 1832 „ 1861 | | 9,412·75 | |
| | „ | „ 1861 „ 1882 | | | 1,109·90 |
| | „ T. H. W. | „ 1832 „ 1861 | | 9,782·75 | |
| | „ | „ 1861 „ 1882 | | | 1,297·40 |
| At Erith Town Causeway - | „ low water | „ 1832 „ 1861 | | 7,488·75 | |
| | „ | „ 1861 „ 1882 | | 2,243·60 | |
| | „ mean | „ 1832 „ 1861 | | 7,650·25 | |
| | „ | „ 1861 „ 1882 | | 1,464·60 | |
| | „ T. H. W. | „ 1832 „ 1861 | | 7,690·25 | |
| | „ | „ 1861 „ 1882 | | 1,405·85 | |

9080. This table gives in parallel columns in square feet, the areas of the cross-sections in 1832, 1861, and 1882 ; that is so, is it not ?—It is so.

9081. At certain places which you have mentioned on those diagrams ?—Yes.

9082. This table gives the increase and the decrease at those various places in the two intervals, from 1832 to 1861, and from 1861 to 1882 ?—Yes.

9083. It is putting into figures, which will appear upon the notes, the points which appear in your section ?—That is so.

Further cross-examined by Mr. Bidder.

9084. You assisted, as we know, at the last inquiry, Captain Calver, who was the gentleman called in to report upon that part of the river ?—Yes, I was with him a good part of the time.

9085. You supplied him with materials for cross-sections and surveys upon which he made certain calculations as to the contents of the river ?—Yes, they were taken from our surveys.

9086. On that occasion you divided the river into five sections running from a little above the Barking outfall down, I think, near to Erith ; one north, and one south ?—Yes, I remember what you mean.

9087. I do not know whether you have any plan with you now showing it, but I think I am right in saying that you numbered the river into five divisions, beginning with No. 1 division at a little above the Beckton Gasworks, and then going down. No. 1 contained the outfall upon the north side, and No. 2 was the intermediate piece between that and Leather Bottle. No. 3 contained Leather Bottle ; No. 4 contained the Southern Outfall, and No. 5 contained Jenningtree ?—That was so.

9088. Do you recollect preparing and putting in calculations from your sections of the low water content of the river in each of those divisions ?—They were put in, but I had nothing whatever to do with them.

9089. Is it the fact that, comparing 1861 with 1879, every one of these divisions showed an increase of content ?—I had nothing whatever to do with these tables, either with the calculation of them or putting them in or anything.

9090. Pardon me, all the calculations with regard to the increase or decrease of the content of the river were got out by your staff and you for Captain Calver ? —They were got out for Captain Calver, but not by me. I know nothing about them.

9091. He mentions in his report with becoming gratitude the services he received from you ?—We furnished him with the Surveys from which these calculations were made.

9092. Do the figures prepared from your survey show that the content of every single division of the river was increased from 1861 to 1879 ?—They are not my figures.

*Mr. Lumley Smith* objected to the line of examination.

9093. (*Mr. Bidder.*) Were they not prepared by you and your staff and in your office for the purposes of Captain Calver's report ?—Excuse me, they were calculated outside of our office entirely.

9094. (*Chairman.*) What are you referring to ?—I am referring to a report by Captain Calver, at page 7.

9095. (*Mr. Bidder.*) I see you said upon that Inquiry that you were with Captain Calver during the whole time that he made the surveys and investigations ?—Yes, I was, undoubtedly, most of the time.

9096. And he was, as I said he admitted in his preface, assisted by yourself and staff in his survey, and your office was the only place from which he could get the materials ?—The materials were obtained from our place ; our office is the only place in which he could get the materials to make the calculation.

9097. And his table shows that every single division in the river increased from 1861 to 1879.

(*Chairman.*) But the last column in the table is for the year 1876.

(*Mr. Bidder.*) That is so in the printed report, but I can find in the print of the Mud Inquiry the further years, if it is thought desirable.

(*Witness.*) I find they did as a rule, but upon the south it is not so.

9098. But you must take the north and south separately, because it so happens that the dredging was upon the north, and the silting up upon the south. Now, taking north and south together, do not all of them show an increase ?—I think it is quite correct as you put it ; it is so, no doubt.

9099. (*Mr. Abernethy.*) Between 1879 and 1881 were not there a number of shoals removed from the river near the outfalls by dredging ?—Yes, there were.

9100. And in other reaches too, were not there ?—No, not in Dagenham, not after 1879 ; but there were extensive dredgings in Erith Reach.

Further re-examined by Mr. LUMLEY SMITH.

*Mr. C. J. More, M. Inst. C.E.*

13 Feb. 1883.

9101. Let me understand about these figures which my learned friend has put into your hands. Are those figures at all calculated by you?—No.

9102. Certain surveys had been taken in your office?—Yes.

9103. And those figures have been calculated from the surveys, and have you examined them, or tested them, or checked them, or do you know anything about them?—I do not say they are not right; I simply say I know nothing about them, I had nothing to do with them.

9104. You handed in figures to-day, showing an increase at Erith?—Yes.

9105. Does that appear at all in the district embraced in that table of figures?—No, that is further down the river.

9106. Does it appear from this table at the places you have taken, viz., at Erith 725 feet above the beacon, and 280 feet above Sand Wharf, that there was an increase in the sectional area between 1832 and 1861, and a decrease between 1861 and 1882?—There is an increase opposite Erith town causeway between 1861 and 1882, but the others all show a decrease.

(*Mr. Bidder.*) But Erith town is just one of the very places at which they complain so much of the mud having accumulated.

9107. (*Mr. Lumley Smith.*) Is that a part where dredging has taken place?—Yes, dredging has taken place in that reach, undoubtedly.

9108. In the section immediately opposite the causeway there has been an increase of sectional area?—Yes.

9109. Is there anything specially to cause that increase opposite Erith causeway; is there any dredging or anything there?—There has been dredging in that reach, no doubt.

(*Sir John Coode.*) It was distinctly put in evidence at an early part of the Inquiry that there had been dredging upon the northern side of the river opposite Erith.

The witness withdrew.

Mr. R. W. PEREGRINE BIRCH, Mem. Inst. C.E., examined.

*Mr. R. W. P. Birch, M. Inst. C.E.*

9110. (*Mr. Balfour Browne.*) You are a member of the Institution of Civil Engineers, are you not?—I am.

9111. If I may so put it, I think you served your time with Mr. Abernethy?—I did.

9112. And in that way, I think, you have had considerable experience in all tidal questions?—I have given my mind to them for several years.

9113. And since you have been practising on your own account, have you given considerable attention to questions connected with the disposal of sewage?—I have.

9114. Were you engaged by the Port Sanitary Authority to make certain tidal observations in the Thames?—I was.

9115. And were the gaugings as to a number of the tributaries put under your charge too?—A portion of them.

9116. And certain instructions in writing were given you, were they not, by Mr. Baldwin Latham?—Yes, as to the float experiments.

9117. And those experiments, if I am not mistaken, Mr. Baldwin Latham put in?—Yes.

9118. By the 7th of September last, had arrangements been made for the daily gauging of all the streams between Barking and Southend?—Yes.

9119. On which side of the river?—On both sides; between Barking and Southend on the north, and between Northfleet and the Isle of Grain upon the south, that was the part under my care.

9120. When did you commence your tidal observations?—We tried to commence upon the 14th, but we got into full working order upon the 17th.

9121. Those operations were under your immediate superintendence?—They were.

9122. And in order to watch them, I think you took up your quarters on board a steam tug called the "Toby"?—I did.

9123. And you were up and down the river watching the men at work for about two months?—I should think that I and my assistants were looking at them for from 18 to 20 hours a day during that time.

9124. And you slept on board the tug?—Yes.

9125. There were six floats, as we know, at the time, and the observations were carried on day and night?—Yes.

(*Sir John Coode.*) Do yo mean that there were six started from each station.

(*Mr. Balfour Browne.*) No; there were six floating in the river at a time.

9126. (*To the witness.*) Only one float was started at a particular time or a particular place?—One float was started upon the 17th of September at high water, another one at half ebb, another one at low water, and three more under similar conditions of the tide on the 22nd.

9127. And you had under your charge a gang of watermen, had you not, whose duty it was to follow those floats in a boat?—Yes.

9128. To each float there was a boat and two men attached, that is to say, attached in the way of watching?—Yes, two men for the day and two men for the night.

9129. And the men who were to relieve, that is to say, the men who were to go on at night, where were they during the time they were off duty, were they on board your tug?—Some of them; or they would go home. We relieved the men by means of the steamer sometimes, and sometimes they came by train to the point at which they were to take up their duty.

9130. Do you believe that the experiments were fairly and properly conducted by those in charge of the floats?—Yes, I believe they were fairly conducted.

9131. Had you brought to your knowledge a single case of misconduct on the part of the men?—No; except that when we discharged a man, we have heard that he had gone to the other side and made mischief; we had heard that, but I never could trace any trickery at all to anybody.

9132. Did you ever dismiss a man for tampering with a float or attaching it to his boat?—Before the 17th we did, but not afterwards.

9133. But not in any of the experiments of which the results are shown in these notes?—No.

9134. Now, according to the papers put in by Mr. Baldwin Latham, they show that whereas the morning ebb is almost always longer than the morning flood, the reverse is the case with the afternoon tide?—Yes; it should be borne in mind that the division between morning and afternoon tides is not a division between the daylight and dark tides. I divided the whole of the diagram out into daylight and darkness to see if I could detect any trickery in the dark, when it is manifestly more difficult to supervise such a job as that than in the day, and I could not find any such thing, and I think if any gentleman on the Commission will look through the diagram, he will see that the floats have behaved very much the same in the dark as they did in the daylight.

9135. Then that fact of the run on the morning ebb being longer than on the morning flood, and the reverse in the afternoon, cannot be explained by any trickery upon the part of the men employed?—Not at all. If there is any trickery proved by the other side, as I gave my whole time to the subject, it will be due to my carelessness, more or less. I have met the men in London at 4 o'clock in the morning and at other places when they did not expect me. I have seen them from the bridges; they had always been told that they had friends watching them and enemies watching them, so that I do not think there could have been much trickery of the kind going on.

9136. You have taken every possible means to avoid it?—Certainly.

9137. With regard to the six floats which you have been mentioning to the Commission, does the distance travelled upon any particular tide represent the maximum or the mean range of the tide?—No.

9138. Will you just explain what it does represent?—The floats were left to take their own course entirely; they were only pushed off when they were likely to touch the shore, so that during a portion of their course they may have been in the best of the tide, but certainly some lateral influence moves them constantly, and they will move from the best of the course to the worst of the course, and from the centre of the course to the side of the course, so that you cannot say that they are in the best of the stream, or in the mean of the stream, or in the worst of the stream.

9139. I need not take you particularly over all the deductions which are to be drawn from the conduct of the floats, because those points have been more particularly gone into by Mr. Baldwin Latham; but I think you will agree with me in this, that the floats, by themselves, are no criterion of the progress of the sewage water towards the sea?—No, not a bit; no one thought they were.

9140. That is evident, because No. 1. was no nearer the sea after it had been in the river for a month than it was when it was put in?—Not at all.

9141. Now, with regard to certain anomalies that appear upon the face of the diagram, is it the fact that the floats upon a flood tide are less affected by lateral influences, such as wind and irregularity of course, than the floats upon the other tides—the neap tides?—Yes, I think it is the greater velocity of the flood tide which accounts for the floats taking a more direct and better course, and therefore a longer journey upon a flood tide than upon an ebb. There is no doubt that the flood tide is considerably faster than the ebb, for this reason. We know that a larger quantity of water comes down with the ebb tide than goes up with the flood, but the time that it takes to come down is increased in a much larger degree than the volume is increased. I have taken the tide of the 1st of October, and I find that at Barking the period of flood upon the 1st of October was 327 minutes, and the period of ebb was 418 minutes. The total volume of water between high water mark and low-water mark above Barking was 2,224,381,325 cubic feet, and during that 12½ hours there was 114,611,250 cubic feet of fresh water, that leaves 2,109,770,075 cubic feet as coming from the sea.

(*Mr. Michael.*) Does that quantity that came over Teddington Weir upon that day, namely, the 114,000,000, represent that water which came into the tidal portion of the river between Teddington and Barking.

*Witness* (*continuing*). The fresh water increases the quantity of water which came from the sea upon the flood tide by about 5¼ per cent., but the time occupied by the ebb tide is 418 minutes against 327 minutes occupied by the flood, so that the relative velocities of the flood and ebb would be as 100 divided by 327 to 1,054 divided by 4,180, or as 30 to 25; the flood tide is therefore 20 per cent. faster than the ebb.

9142. You have put that in a tabular form, have you not?—I have.

*The same was handed in and was as follows:*

*Mr. R. W. P. Birch. M. Inst. C.E.*

13 Feb. 1883.

Figures showing that the velocity of the *Flood Tide* at Barking is greater than that of the *Ebb Tide*.

(Taken from Erith and Deptford Tide Guage Diagrams, referring to 1st October 1882.)

Low water at Barking 10.4 a.m.

| | | | |
|---|---|---|---|
| High water | do. | 4.10 p.m. | Interval 327 minutes. |
| Low water | do. | 11.8 p.m. | Interval 418 minutes. |

Total volume of water above Barking, between Barking high water and Barking low water line = 2,224,381,325 cubic feet.

| | |
|---|---|
| Made up of land water* | 114,611,250 „ |
| And tidal water | 2,109,770,075 „ |

The volume of ebb from above Barking on this day is consequently, by reason of the land water, 5·4 per cent. greater than the previous flood. But the time occupied by the ebb is (see above) 418 minutes against only 327 minutes taken by the flood.

The relative velocities then of flood and ebb will be as $\frac{100}{327}$ to $\frac{1054}{4180}$ or as 30 to 25. The flood is therefore 20% faster than the ebb.

* 152,815 cubic feet per min. × 12½ hrs. × 60 min. = 114,611,250 cubic feet in the tide.

9143. That, I understand, shows that the velocity of the flood tide is greater than that of the ebb?—Yes.

9144. Will that, to your mind, account for the floats taking a better course and a longer journey, up the river than down?—Certainly.

9145. If the flood tide is the stronger it would minimize the effect of the wind or any other obstruction?—Yes.

9146. So that a good many of the anomalies would be accounted for by the true course kept by some of the floats, while others have not kept so true a course?—That is so, it is entirely a matter of steering.

9147. And the men were not allowed to steer a float, but only to move it when it got aground?—That is so.

9148. Then would it go to show that the up tide being stronger than the down tide, would have the effect of carrying up any deposit from the mouth of the outfall and depositing it higher up the river; is that the tendency?—Certainly it would.

9149. What is the agent which principally effects the scouring in the river; is it tidal water or is it fresh water that comes over Teddington Weir, and falling into the river with that of other tributaries below?—It is the new water; the fresh water from the river and the new water from the sea that carries away the sewage.

9150. Not the water which is swaying backwards and forwards, and knocking about?—No, certainly not.

9151. What proportion does the upland water form of the total water that would scour out the sewage. Have you come to a conclusion as to that. You say that the upland water plays the important part in scouring out the river?—My point is, that the amount of water oscillating between Crossness and Barking, though it may have a great scouring power upon the bottom, has no effect in carrying out the water and sewage to the sea; it is simply the shaking of a vessel which is being filled upon the one side and emptied on the other: but the shaking of the vessel has no effect upon the emptying or the filling.

9152. Then upon what circumstances would the quantity of sewage leaving the river depend?—Upon the quantity of fresh water coming in.

9153. That, of course, depends upon the up country rains, and the character of the tides at the time?—Yes, quite so.

9154. Have you worked out the particulars for three distinct days, the 14th and 22nd of September, and the 30th of November?—I have. I have worked out in diagrams what Mr. Latham and Mr. Mansergh worked out in tables.

(*Diagrams were handed in. See Appendices A.B.* 1, 2, 3.

9155. I think in one other circumstance you have varied your procedure from that adopted by those gentlemen. They took absolute high and low water,

*Mr. R. W. P. Birch, M. Inst. C.E.*

13 Feb. 1883.

and you have worked throughout upon the mean?—Mr. Latham and Mr. Mansergh are gentlemen with much greater experience than I am; but I have worked it out with great detail, and with every possible correction I could think of; and the result is practically precisely the same.

9156. You have worked it out in another way and have arrived at very nearly the same result?—Yes, there is hardly any difference between us.

9157. You have, I think, taken three distinct days. Now, there was a spring tide upon the 14th of September?—Yes, the tide upon the 14th of September was a spring tide.

9158. And what was the flow at Teddington Weir?—8,332 cubic feet per minute.

9159. The 22nd, which is upon the second diagram, was a neap tide with rather more water over Teddington Weir, the flow being 122,451 cubic feet per minute?—Yes.

9160. And the tide of the 30th of November was half way between spring and neap, was it not?—Yes.

9161. With a flow of 476,345 cubic feet?—That was a very great flood.

9162. Will you just explain your first diagram?—The first diagram shows the respective quantities of sea water, inland water, and sewage in the various reaches of the Thames upon the 14th of September 1882, and it shows that the northern sewage of the 16th of August, mixed with the Teddington water of the 4th of August, reaches Southend upon the 14th of September, taking 30 days to do the journey, the sewage, being when it arrives at Southend 30 days old, that is to say, from Barking to Southend.

9163. Your diagram begins to figure at Barking?—Yes, the sewage of the 16th of August gets to Southend upon the 14th of September, and the Teddington fresh water of the 4th of August gets to Southend on the same day. Every day's upland water and sewage which affects this diagram is localised longitudinally by the red lines across the white column, and its volume is shown in cubic feet by red figures upon each block, and each of those blocks is supposed to contain 26,000,000 cubic feet of sewage. From that the proportion of sewage in the river can be ascertained.

9164. What do the red figures at the north of that white indicate, September 1st and August 31st?—They show the day upon which each block of water came over Teddington Weir.

9165. So that beginning at the top, that water which arrives in Barking upon the 14th of September came over Teddington Weir upon the 2nd?—Yes.

9166. Take Erith; that water which arrives at Erith upon the 14th of September passed over Teddington Weir upon the 28th of August?—Yes.

9167. And so on, all the way down until you come to the very last, which shows that the water which was at Southend upon the 14th of September left Teddington upon the 4th of August?—Yes.

9168. Each block of water, as it carries the sewage of the day with it, passes through that column, accordas the column of tidal water comes back to displace it, and carry it to the sea?—Yes.

9169. This white column seems to diminish as it goes down?—Yes.

9170. So that apparently there is at Southend less fresh water than there is higher up?—There is a smaller column, but it is travelling faster.

9171. That is why the white seems smaller at Southend than it is up at Barking; the same amount is passing through, but it is going more rapidly, and therefore the sectional area is smaller?—Yes; this diagram shows all the fresh water as though it were collected to one centre. Of course, it is not so, it may be distributed in millions of fibres; but we have collected it all together and shown it as occupying that body of the channel; that is the only means, I think, of calculating the rate of progress of fresh water in any tidal estuary; this diagram is not, of course, a true plan, it is a developed plan.

9172. (*Sir John Coode.*) The width represents the proportionate sectional area of the river, if I understand you rightly?—It represents what width the river would be if it were one foot deep all over; that makes it appear much wider at the mouth of the river than it would otherwise do.

9173. (*Mr. Balfour Browne*). Now at Southend, you say it is the same quantity of sewage which is passing, but it is passing more rapidly and therefore of course filling a smaller sectional area?—Yes, quite so.

9174. To what do you attribute the greater rapidity of the column of water at Southend?—Because the sea water coming in reduces the cross sectional area, and as soon as you reduce that, if you have a regular supply of fresh water, you have *pro tanto* an increase of velocity.

9175. If you increase the sectional area of the river through which the fresh water and sewage have to flow, of course you would get the rate of progress slower?—Yes.

9176. On the other hand, if you decrease the sectional area by the coming in of the tide, you get it faster?—Yes. The long and the short of this diagram is that it shows that the velocity is not reduced as the river gets wider, as it would be supposing the whole of the river channel had to be filled up before the water could be displaced into the sea. But for the action of the sea water, the velocity at Southend would be a 12th of the velocity at Barking; but as a matter of fact the velocity at Southend is really a little faster than the velocity at Barking.

9177. That fact is also brought out, though not diagrammatically, in Mr. Latham's and Mr. Mansergh's tables by figures instead of diagrams?—Yes.

9178. What is all this founded upon; is it founded upon mere displacement or upon the chlorine tests?—It is founded upon the salt tests, which tell us how big the fresh water column is, and when we know how big the fresh water column is, we know how fast that fresh water column must travel to carry out a given quantity of water. Now it was suggested that we have taken the wrong standard.

9179. Is 1961 the wrong standard, or what do you say to it?—No; it is absurd to say that it is a wrong standard; we found on some days, at Southend, water with 1938 grains of chlorine in it, so it is quite clear that within the tidal range of Southend, there must be water quite as strong as 1960; and we also found at Margate salt water as strong as 1950 odd; we should not expect to find the saltest water close to the shore where a river runs down, but I have no doubt that in the centre of the estuary you would find that the water would have, as a normal quantity, 1960 grains of chlorine in 100,000.

9180. Is that figure 1961 corroborated by the figure I find in Mr. Way's tables, which Mr. Latham put in?—Yes it is.

9181. I find at Southend upon the 14th of September, that the chlorine in 100,000 parts of water was 1931 does that corroborate to your mind the accuracy of the standard of 1961?—Certainly; after this water has come up from the centre of this estuary to Southend and been mixed with fresh London water it still has 1931 parts of chlorine, and I cannot imagine that it could ever have had less than 1960 at Margate; to put it as low as 1700 would be absurd.

9182. On another day I find the chlorine at the same place, at Southend, is 1785; what does that indicate to your mind?—That there is a large quantity of upland water amongst it, as shown upon the later diagram. I think I should explain to the Commission that the line upon the upper side of the dotted line shows the limit of the high water capacity, the lowest hard blue line shows the low water capacity; and the two outer dotted lines and the two inner dotted lines show respectively the limits of the mean river capacity, and the mean fresh water column. It is a point which ought to be explained that the limits of the mean fresh water column are wonderfully near the limits of the high water column

upon the upper side, and to the limits of the low water column upon the lower side. If you look at the lower column of the 22nd it is especially so ; the mean line is very near the high water line upon the upper side, and very near the low water line upon the lower side, so I think we are justified in taking the mean as the average column of the day.

9183. Just to make these figures, which are put crossways upon the diagram, perfectly clear, you see it begins with 188,000,000 cubic feet?—That is upon the 14th of September diagram.

9184. That is the amount of water that came over Teddington Weir upon the 2nd of September?—Yes.

9185. The next happens to be the same?—Yes.

9186. That is only a coincidence?—Yes.

9187. The next again is 171,800,000, a smaller quantity came over on the 31st of August than upon the preceding two days?—That is so.

9188. (*Sir John Coode.*) Those are cubic feet in 24 hours, are they not?—Yes.

9189. Where were they taken from?—They were taken from Mr. Latham's tables, as far as the tables exist. We were obliged to take the earlier ones from heights that we could get from Mr. More, and we would say the water was 7 feet 6 high upon the 3rd of September, and it was the same height upon the 20th of September, and we know what the discharge was upon the 20th of September, and we take the same discharge as existing upon the 3rd.

9190. (*Mr. Balfour Browne.*) So that where you could, you have taken exactly Mr. Latham's figures, but, where it was necessary, you have supplemented them in the way you describe?—Yes, where Mr. Latham's figures exist, we have used them.

9191. This wave line represents upland water mixed with sewage?—Yes, you may get the proportion of sewage in the river in that way; you have 26,000,000 in 185,000,000, for example, that gives the proportion of sewage to fresh water, then you have 50 or 60 per cent. of fresh water by the side of the white block, which increases the proportion of the dilution which may be ascertained by measurement.

9192. Will you just turn to your No. 2 diagram, a similar process has been carried out there, only for the 22nd of September instead of for the 14th?—Yes.

9193. And this again represents the actual facts happening on that day?—Yes, the picture shows you exactly the quantity of fresh water there is in the river, and the statistics we have about the daily flows show you how that column must have been made up.

9194. And here again, we see that upon the 10th of September the water coming over Teddington Weir had arrived at Barking upon the 22nd of September, and that the water coming over Teddington Weir upon the 10th of August had arrived at Southend upon the same day, the 22nd of September?—Yes, having in it the sewage of the 22nd of August.

9195. (*Mr. Michael.*) But you have added 22, have you not, in every case?—No, it is a difference of 12 days, if you put the 22nd of September in the left hand division you will get 12 days.

9196. (*Mr. Balfour Browne.*) Because it took 12 days for the water from Teddington to come down to Barking, and then it got the sewage of Barking?—Yes ; upon the 22nd of September there are 12 days' fresh water in the river between Teddington and Barking.

9197. Now, with regard to diagram No. 3, that was taken upon the 30th of November; what was the condition of the river upon that day?—There was from four to five times as much water in it as in the two given days in September.

9198. That is to say, it was comparatively a flood?—Yes.

9199. The effect of that is shown diagramatically as compared with the last diagram?—Yes.

9200. What happened upon that day?—It shows that the sewage of the 19th of November reaches Southend upon the 30th of November. This is the only one which is not, upon the face of it, exactly the same as the table, or which does not give exactly the same result as the table. That is because Mr. Latham and Mr. Mansergh showed that it would take, upon the average, 13 or 14 days in that particular condition of the water, if there were an average flow equal to that of the 30th of November, but there was a greater flow before the 30th of November, and that greater flow reduces the number of days, but the fresh-water columns described in Mr. Latham's tables and Mr. Mansergh's tables are almost exactly the same as the fresh-water column in this case.

9201. This seems to show the greater importance of the sweeping out of the sewage to sea by the fresh water from the upland?—Yes.

9202. Might we go backward, and say that as the fresh water diminishes in the summer season these other two diagrams do not indicate the very slow progress which would then be made in the very hot and dry weather?—No, of course not, if you increase the velocity as we have shown it here, by an increase of fresh water, so you obviously increase the time it takes if you reduce the volume of fresh water in a hot summer.

9203. So that you would reason back and say, these mean periods were not at all indicative of what would take place in the height of summer?—Certainly not.

9204. But that a much longer period would be required to take the sewage down to Southend in a hot summer?—Certainly.

9205. (*Chairman.*) I understand your last table to show that upon the 30th water had reached Southend which had come over Teddington Weir on the 16th and passed Barking on the 19th?—Yes.

9206. So that there is only three days flow between Teddington and Barking in that case as compared to the 12 days which there had been in the former case?—Yes ; there was about from four to five times the quantity of water that there had been in the former case.

Adjourned to to-morrow at half past 12.

# TWENTY-SECOND DAY.

## Wednesday, 14th February 1883.

PRESENT:

THE RIGHT HONOURABLE LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR P. BENSON MAXWELL.
SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANCOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary*.

MR. R. W. PEREGRINE BIRCH, Mem. Inst. C.E., further examined.

*Mr. R. W. P. Birch, M. Inst. C.E.*

14 Feb. 1883.

9207. (*Mr. Balfour Browne.*) It has been suggested that possibly yesterday you did not make clear enough to the members of the Commission the means by which you ascertained the progress of the upland water through the tidal estuary of the Thames, and, moreover, his Lordship was for a short time absent. Could you give just a simple explanation of the method you adopted which would make the matter clearer to the minds of the Commission?—I have prepared a short description of my view of the reasoning upon which I think the matter is based. We know from the gaugings of the river which have been made for several months the quantity of upland water reaching the tide way daily, and we know, taking one day with another, that as much water must go out of the river as comes in; so we may say that we know the daily quantity that passes through the river. So the question is, what speed that daily quantity must travel in order that the known quantity of water supplied to the river may be discharged. This would be a simple matter if we could see the column of water it formed running in a regular channel unoccupied by anything else, or falling over a weir so that we could measure its width and depth, for we should then learn by actual measurement the cross-sectional area of the column. It is the cross-sectional area that we want to get in order to get at the velocity. Then, by dividing the day's supply in cubic feet by the sectional area in square feet, we may ascertain with acuracy at once the day's progress towards the sea.

9208. That is if you could see the column?—Yes, if we could see the column; but we cannot see the column. Now, supposing the upland water supply to be 100,000 cubic feet per minute, this would pass through a column half a mile wide and 30 feet deep, if outside influences so dictated, just as easily as through a column twice as large; only, if it passed through the smaller column, the velocity would necessarily be just double.

9209. (*Sir John Coode.*) You mean through a smaller channel?—Yes, quite so. I call it column because it is not confined by any physical hard boundary.

9210. You are assuming a bulk of fresh water running through a quantity of salt water?—Yes; you get the same column of water running from a hose or jet, which has no physical hard limit, as you get inside a pipe, the diameter of which you can measure.

9211. If we can ascertain the cross-sectional area of the column we know the velocity at which it travels. We cannot, however, see the fresh water column, because it passes through a much larger mass of sea water, and so, to ascertain its size, we use salt tests which tell us what proportion of the whole mass of water is fresh water and (what is the same thing) give us the cross-sectional areas at a number of points down the river of the fresh water column. I do not know whether his Lordship saw the diagram we put in yesterday. I do not suggest that the fresh water passes through the salt water in one defined column, as is shown upon that diagram, for there is no doubt it passes away in myriads of small streaks; but the salt tests give us this combined volume, and, for the purpose of progress calculations, it matters not whether the fresh water be found in one large column or an infinite number of small streaks.

9212. If you could see the column, of course it would be all easy enough?—Quite so.

9213. But as you cannot see the column, then by the salt test you find how much salt water there is in the river, and therefore how much room is left for the fresh water?—Yes, we probe through the salt water until we come to the fresh, and find what room there is for the fresh water column. By ascertaining the amount of chlorine you learn the amount of salt there is in the water.

9214. Will you point out upon the diagram the portion of the channel occupied by fresh water at any point, and show the Commission how you arrive at it, taking one day of course; which day are you going to deal with?—The 14th of September (*placing the diagram before the Commission and explaining it*). We learn that the fresh water is $\frac{15}{1000}$ of the total water at Southend at high water; in the same way, at low water, the fresh water is $\frac{1}{10}$ of the total water. The mean fresh water bears the same relation to the mean salt water as that white space does to the blue between the dotted lines. We have applied the same process to an analysis made at five or six different points. We have interpolated the proportion of chlorine between the different points, and this is the result, that, as regards the progress calculations, we have a column of water represented by the white space instead of a column of water of this shape (*pointing to the blue*). The result is that the water travels even faster at Southend than it does at Barking, though there is a larger cross-section; the cross-section is twelve times as great at Southend as it is above.

9215. (*Chairman.*) What does this ultimately prove?—It ultimately proves that the sewage which went into the river upon the 16th of August reaches Southend upon the 14th of September—that is 30 days.

9216. That is to say, it reaches it for good?—Yes.

9217. And never comes back again?—No; that is the mean of the oscillation.

9218. Sometimes it is below Southend, and sometimes it is above Southend, but in the mean it is at Southend?—Yes.

9219. And is 30 days getting there?—Yes.

9220. (*Sir John Coode.*) The contrast between the white and the blue represents the relative volume of each?—Yes.

9221. This is rather of the nature of a sectional diagram than a ground plan?—Yes, it is not a ground plan. I explained yesterday that it represents the river as though it were a foot in depth, and of proportionate width. The Metropolitan Board of Works admit that it would go down only half a mile a day, but for something outside which makes it go faster. We think that we have dealt conclusively

with that outside lement to show how much faster it does go; that diagram is taken upon the 14th of September. This (*producing the second diagram*) is a very similar diagram taken upon the 22nd of September. There was rather more water then in the river than upon the average.

9222. Was the tide upon the 22nd spring or neap?—One is spring and the other is neap. For this month we must take the mean between the two for the progress, as they were not all neap, and they were not all spring tides.

9223. Upon which do you make it get soonest to Southend?—It depends on other outside influences.

9224. You mean to say that it depends more upon the volume of fresh water than upon the tide being spring or neap; that is the purport of your answer?—Yes. With regard to the tides we may take the mean between high and low water as a fair average of the whole day. Then when we come to the 30th of November we have a very different state of things. That means that there are three days between Teddington and Barking, instead of 12 days, as there were before. Upon the 30th of November we find that the rate of progress is altogether between Barking and Southend $11\frac{3}{4}$ days.

9225. The water which came over Teddington Weir on the 16th appeared at Barking on the 30th, and I see that the water coming over Teddington Weir on the 16th was 560,098 cube feet per minute?—Yes; this (*pointing to the diagram*) gives the daily flow in cubic feet. It is no part of our case to show how very rapidly the sewage goes out in flood time; but there is one inference from it which is in our favour, and that is that, if by increasing the quantity of fresh water you make the sewage go out so much faster, on the other hand, by reducing the quantity of water to the summer condition of things you make it go out so much more slowly.

9226. (*Mr. Balfour Browne.*) You had no opportunity of making one of these diagrams when the water in the river was going very slowly?—No; but I should like to have the thing done for weeks and weeks.

9227. You assume, seeing that it went out so rapidly upon the 30th of November, that in summer it would go out at a very much slower rate, though you have no means from observation of calculating the number of days?—No, I should not like to say what the rate of progress would be.

9228. (*Chairman.*) You could not take the average throughout the year, because if you had two months of almost stagnant water you would have mischief done then which could not be compensated by increased flow at another time?—Certainly not.

9229. (*Mr. Balfour Browne.*) Upon this occasion, the 30th, when it went out so rapidly, that was, of course, an occasion upon which there could be no nuisance from the sewage?—Of course.

9230. It is not during the month of November that a nuisance ever arises?—That is so.

9231. There is a point I was puzzled with upon the diagram No. 1. If you look at the white, which represents the sectional area of upland water and sewage, the column diminishes in thickness as you get to Southend?—It does.

9232. Why is that?—Because there is a large quantity of salt water which comes in from the sea and reduces the channel.

9233. The same quantity of fresh water must, of course, be passing through that section at Southend, but it is passing at a more rapid rate?—Yes.

9234. And therefore the sectional area it gets through must, of course, be smaller?—Quite so.

9235. Just to take one or two general questions upon these diagrams, looking at the one of the 14th of September, that shows that a certain amount of water and sewage was between Barking and Southend. What number of days flow of inland water and sewage would that represent?—30 days' sewage.

9236. There were 12 days' upland water above Barking?—Yes, the days between the 2nd of September and the 14th.

9237. That was water that had come over Teddington Weir 12 days before?—Yes.

9238. Now, as to the other diagram. Upon the 22nd of September, in the same way, how many days flow of inland water and sewage were between Barking and Southend?—32 days.

9239. That began upon the 10th of August, did it not?—Yes.

9240. And ended upon the 22nd of September?—Yes.

9241. What number of days flow of inland water was above Barking upon that date?—12 days.

9242. Now, passing to the 30th of November, how many days of inland water and sewage were between Barking and Southend upon that day?—$11\frac{3}{4}$ days, beginning upon the 16th of November and finishing upon the 27th of November.

9243. Then those diagrams, as I understand, show both the age and the amount of the dilution of the sewage?—Yes, quite so.

9244. In September, for instance, the northern outfall sewage passed Erith about from five to six days after it had been emitted; that is to say, when it was five or six days old?—Yes, from five to six days old.

9245. I think I heard you so explain to his Lordship that, altogether apart from its progress to the sea, the sewage has been swinging backwards and forwards over the 6 miles radius?—Yes, quite so. These blocks represent the centres.

9246. When it gets there it is on its final progress to the sea?—Yes.

9247. It was six days old when it passed Erith?—Yes.

9248. And was diluted upon the 14th by how many times the water that it was upon the 22nd of September; can you tell the bulk of water that was diluting it at that point?—On the 14th it was diluted by eight times its bulk, and upon the 22nd by 14 times its bulk of other water, and upon the 30th by 30 times its own bulk of water.

9249. All that, I believe, appears in your diagrams?—Yes; and the same thing is shown by the tables which Mr. Latham and Mr. Mansergh put in.

9250. As you explained it yesterday, this only shows diagramatically what was shown by the tables of Mr. Baldwin Latham and Mr. Mansergh?—Yes, that is so.

9251. Now, taking Greenhithe upon the 14th?—The sewage was there about 10 days old.

9252. And how much was it diluted?—It was diluted by rather more than 14 times its bulk of water.

9253. Upon the 22nd by rather less?—Yes, by rather less than 14 times its bulk.

9254. And upon the 30th of November?—Upon the 30th of November, during that great flood, the sewage passed Greenhithe about three days old, and was diluted by 45 times its bulk of water.

9255. Take the same with regard to Gravesend?—In September it passed Gravesend about 16 or 17 days old, and was diluted upon the 14th by about 21 times, and upon the 22nd by about 16 times its own bulk of other water.

9256. We find upon the 30th that it was some five or six days old when it passed Gravesend?—It was five or six days old when it passed Gravesend, and it was largely diluted by 63 times its bulk of water.

9257. Now will you just give me the same figures from your notes as regards Southend?—At Southend in September the sewage was from 30 to 32 days old, and was diluted on the 14th by 184 times and on the 22nd by 149 times its own bulk of other water. On November 30th, at the same place, the sewage was about $11\frac{3}{4}$ days old, and was diluted by about 305 times its own bulk of other water, always showing the great effect of the increased volume of water.

*Mr. R. W. P. Birch, M. Inst. C.E.*

14 Feb. 1883.

9258. You told the Commission that all these deductions depend upon the chlorine test?—Yes, they depend upon the chlorine or salt tests.

9259. It was suggested by my learned friend, Mr. Bidder, in his cross-examination, I think it was, of Mr. Mansergh, that in estimating the chlorine we had taken the wrong figure; that it ought to be 20 parts in 100,000 instead of 10, which our witnesses had taken it at, in sewage; have you calculated what difference it would make in your calculations of the 20 parts which Mr. Bidder stated had been taken instead of the 10 grains?—It would make absolutely none.

9260. Will you show how that is?—If we had increased the quantity of chlorine in the sewage from 10 to 20 parts in 100,000 parts we should have increased the chlorine in the upland water by 1 part in 100,000 parts; and if we had increased the quantity of chlorine in the upland water by 1 part in 100,000 parts we should have affected the size of the column at any particular place; that is to say, the proportion of fresh water to salt, by $\frac{1}{1959}$th part, which is about $\frac{1}{20}$th per cent.

9261. Supposing the 20 parts had been taken instead of the 10, have you worked out how much difference in the time it would have made between the sewage being poured in at Barking and reaching at Southend?—One part in 1950 means a difference of about 20 minutes a month; so that the analysis of the sewage, whether correct or incorrect, makes but 20 minutes difference in the period taken to travel from Barking to Southend.

9262. So that it is not a very serious matter if it only makes a difference of 20 minutes in a month?—No.

9263. There was a suggestion that the Medway water came up the river, and vitiated the results which are got from the chlorine tests. My learned friend Mr. Bidder made that suggestion yesterday. What do you say to that?—I do not think he could have been in earnest, because we find that about a fiftieth part of the sea water at Southend comes up to Barking. We also find that in order to get that quantity of sea water up there, the sea water at Southend must be 20 times as great as the Thames water at Southend. In order to drive the Medway water up in that proportion, which, as I will show you directly, is remarkably small, and does not affect the column at all, we should have to make the Medway, which is only a tenth part of the Thames, 20 times as big as the Thames; and then we should have to give it the property which sea water only has of a much greater specific gravity, which is the only force which drives the salt water up the river.

9264. (*Sir John Coode.*) You mean, I suppose, to say that the effect of the tide is to drive the fresh water of the Medway back up the channel of the Medway, and not up the Thames?—No, that is not what I mean.

9265. Will you kindly explain what you mean? You say that the Medway water does not come up the Thames?—No, not appreciably.

9266. Will you explain how you show that?—We know that in the Thames at Barking there is a quantity of water which did not come down the Thames, which must have come from seawards, equal to a 50th part of the sea water at Southend. Now, it follows from that, that only a 50th part of the sea water at Southend can get up to Barking. Now, it is suggested on the other side that the Medway water gets up to Barking. Only a 50th part of the sea water at Southend can get up to Barking, and a 50th part of the whole Medway would be only a 500th part of the Thames; so that, supposing the circumstances were most favourable, we could only get a quantity of Medway water at Barking equal to a 500th part of the river water at Barking, and we do not profess that our calculations are nearer than a 500th. There may be an error of a 500th, and I should be very pleased if there were no greater error.

9267. You said that what brought the sea water up was its greater specific gravity?—Quite so.

9268. Therefore there would be no tendency for the fresh water of the Medway, which is of less specific gravity, to come up at all?—No, not at all; the tendency would be for the water of the Medway to go out just as the water of the Thames does; to scramble, as it were, for a place to get out.

9269. (*Mr. Abernethy.*) The water at the mouth of the Thames is almost entirely sea water?—Yes.

9270. And the sea water being of greater specific gravity would not permit the fresh water of the Medway to find its way up the Thames, the tendency would be for the water of the sea to displace the fresh water?—Yes, quite so; there must be just as great a tendency for the Medway water to get out of the river as for the Thames water to get out.

9271. (*Chairman.*) As I understand, when river water runs into the sea it becomes a mixture of two waters?—Yes.

9272. And it is that mixture which runs up the river?—Yes.

(*Dr. Stevenson.*) You say that the salt water has a greater tendency to run up than the fresh water. I do not follow that.

9273. (*Sir John Coode.*) Is it not rather the rise of the tidal column which causes the water to run up the Thames than the greater specific gravity?—If it were only for the rise of the tide, the fresh water would be dammed back by the salt water. What makes the sea water penetrate the fresh water is the greater specific gravity of the sea water.

9274. It may make it penetrate it, but it is the rise of the tidal column which drives it up?—Certainly, which drives it up; but the thing which makes the two things mix is the greater specific gravity.

9275. (*Mr. Abernethy.*) Supposing this is the Medway and this is the Thames (*drawing a diagram*), both flowing into the sea at a common point, a very small portion of the water from the Medway is mingled with the sea water at that point?—Yes.

9276. The flood tide comes from the North Sea, does it not?—I suppose it does.

9277. The tidal column rises and the tidal column is entirely sea water; how can any fresh water passing from the Medway displace the column of tidal water passing up the Thames?—I do not quite grasp the point of your question.

9278. No fresh water from the Medway can displace the tidal volume of water which is flowing up the Thames?—It would mix in a small quantity; but only a very small proportion of the water at Southend can get up. We have shown that a 50th part of the salt water at Southend gets up to Barking; therefore if only a 50th part of the Medway water did get up, it would be perfectly ridiculous in a river 10 times as big as the Medway.

9279. (*Mr. Balfour Browne.*) Supposing the fresh and the salt water were of exactly the same specific gravity, would the effect of the tidal column coming in be simply to raise the fresh water as against the salt?—Yes.

9280. But the fact being that the heavier tidal water coming in raises the fresh water, there is therefore, through the greater specific gravity of the salt water, a diffusion of the salt water through the fresh?—Yes, quite so.

9281. This diagram of yours shows how the fresh water is got rid of at the mouth of the Thames?—Yes.

9282. This diagram is true of the Thames, and the same is also true of the Medway?—Yes, perfectly.

9283. When the fresh water comes down the Medway it is disposed of by the sea exactly as the fresh water coming down the Thames is disposed of; am I right in that?—Yes; but even if the whole of the Medway water presented itself right in the centre of the Thames, then only a 50th part of the Medway water could go up the Thames; and a 50th part of the Medway water in a river 10 times as big as the Medway must only make a difference of a 500th part, which is quite inappreciable in our calculations. I should mention that of course this difference of specific

gravity acts quite as strongly upon the Medway water to take it out into the German Ocean as it does upon the Thames water.

9284. Have you built any argument upon the salt survey with regard to the sewage pollution above Barking?—No. I have applied this salt process simply to the river between Barking and Southend; but there can be no doubt that with every flood tide the sewage discharged upon the last of the ebb must go up very nearly the whole range of the tide; it must go up 11 or 12 miles.

9285. Being discharged upon the last of the ebb, it therefore is carried up upon the first of the flood?—Yes, leaving a streak of sewage behind it from 12 miles above the outfall down to the outfall.

9286. While you were on the river, was the water at all favourable to the development of any nuisance from the sewage?—No, certainly not; from the middle of September to the early part of November it was cold, and we should not have perceived the nuisance that people complained of in summer.

9287. But having been from six to eight weeks upon the river, I daresay you can tell the Commission what was the appearance of the surface of the river even when you were on the river?—It must be very striking I think, to anybody who is constantly passing up and down the river; that is to say, the floating sewage. I have drifted up in a steamer amongst the sewage and seen the most undisguised sewage upon the surface up as high as Blackwall, and down the river certainly as low as Purfleet, pretty nearly every day, either floating in the currents or lying on the side marking the distinction between the slack places and the stream.

9288. In standing below the paddle-box, could you distinguish the sewage in the river from the spray?—I was reminded of the sewage more in that way than in any other way. Standing on the sponsons of the tug, the spray from the water would come in your face, and you would be then reminded of the sewage most distinctly. I have noticed that as far down as Erith on more than one occasion.

9289. Now, with regard to the temperature, I think you have something to say; I think there were temperature tables made by Dr. Collingridge?—I know they were generally low. I do not know how high they were, but they were considerably below the summer temperature.

9290. And that would to some extent account for the river not being a nuisance at the time that you were upon the river?—Certainly.

9291. Do you remember the 22nd of October?—Yes.

9292. Were you on the river on that day?—Yes, I was. I had occasion to go up Deptford Creek; it was after a considerable amount of rain. I went up Deptford Creek, and there I found that no doubt the storm overflows were at work, and I saw more solid sewage floating upon the surface of the water than I ever saw floating on the surface of any water in my life before.

9293. That was discharged from the storm overflows?—Yes.

9294. (*Chairman.*) That was at Deptford Creek?—Yes. I think that must be a serious disadvantage to people having property in the Creek.

9295. When you say sewage, do you mean to say that it was the excreta of people?—Yes.

9296. (*Colonel Ewart.*) Was it in large quantities?—Yes; it was apparently the strongest matter in the form of sewage that I have ever seen.

9297. (*Chairman.*) What was the tide running then?—I cannot say, but I can give you the time; it was a quarter to 12 upon the 22nd of October.

9298. That is when you were there?—Yes. On reference to the tide tables, it appears to have been about half ebb.

9299. (*Colonel Ewart.*) Which side was it coming from?—It was in the middle of the stream in Deptford Creek. I cannot say which side of the creek it came from.

9300. (*Mr. Abernethy.*) Your diagram is based upon the supposition that all the sewage passes from Barking downwards to the sea?—Yes, so it does.

9301. That is the basis of your calculation, is it not, that all the sewage discharged at Crossness and Barking passes downwards to the sea?—Yes.

9302. And there it is all held in solution?—The calculation does not depend upon that. When I talk about sewage, I mean simply the water which has passed through the London sewers. I have not gone into the question of how that is altered. Any water that has gone through the London sewers I call sewage.

9303. (*Mr. Balfour Browne.*) We rather are dealing with the column of fluid throughout?—Yes, certainly.

9304. This diagram does not depend at all upon any solid matter at the bottom of the Thames, but only deals with the column of water coming from the sewers?—Certainly. The only thing that bears upon the deposit at all is, as I said, that the flood tide was stronger than the ebb tide.

9305. You told us yesterday that the flood was stronger than the ebb, and that that would have the effect of sweeping it up the river, and unless the scour were considerable that would not have the effect of floating it out upon the ebb?—Quite so.

9306. I want you to point out to me Deptford Creek upon the map. (*The same was pointed out.*)

9307. That is where the storm overflow of the Metropolitan Board of Works comes in?—Yes. I did not go up to the outfall. I only saw the sewage; I was about 100 yards from the creek's mouth.

9308. (*Chairman.*) This was floating sewage, was it?—It was floating out of the creek with the stream.

9309. (*Sir John Coode.*) But from the storm overflows?—I presume so.

9310. (*Chairman.*) You do not mean that it was from the regular discharge of the sewers?—Not at all. I did not see it come from the storm overflows, but I am convinced that it did come out from the storm overflows.

Cross-examined by Mr. Michael.

9311. Did you see sewage coming down from the storm overflows at any other period except the one you have mentioned?—I was not much in that part of the river where the storm overflows were.

9312. That was the only time you saw it?—I was not in that part of the river where the storm overflows were. I was below bridge a long way.

9313. You were asked about the chlorine tests, whether you had merely taken the matter in solution, and passed over the matter in suspension?—Yes.

9314. Chloride of sodium is a soluble matter, and if there were any chloride of sodium in the suspended matter, that would be dissolved out and washed down by the tide?—Yes, I suppose so.

9315. Taking your period of the 14th of September, the sewage, I understand you to say, was 17 days in the reach of water between the outfall and Gravesend?—No, that is not so.

9316. Take your own time, and let me know if you can make out the time in which any gallon of sewage turned out from the outfall, say upon the 14th of September, would reach Southend?—I cannot deal with that. Take one put out at Barking upon the 16th of August, that reaches Southend upon the 14th of September.

9317. How many days is that?—30 days.

9318. Take a gallon of the sewage and tell the Commission through how many miles that gallon of sewage would have travelled in the water during that period?—You mean how many miles it would have been shaken backwards and forwards.

9319. How many miles would it have travelled in that period?—30 times 50.

*Mr. R. W. P. Birch, M. Inst. C.E.*

14 Feb. 1883.

9320. That would be 1500 miles according to my arithmetic; but that would have to be doubled?—Take 12½ miles each ebb and each flow, and there would be two tides each way in a day.

9321. It is 50 miles to Southend?—It would be shaken backwards and forwards, no doubt, and mixed, and whatever advantage you can get out of the mixing would have taken place.

9322. Take a gallon of sewage which had traversed 1500 miles of running water, what would it be at the end of that period?—I do not think you can take it in that way.

9323. But I want to take it in that way. A gallon of sewage sent out from an outfall into a running river and travelling 1500 miles, what would the condition of that be *qua* sewage at the end of that period?—I do not know the least in the world.

9324. But you have constantly given your attention to matters of drainage involving questions of this description?—If the people at Southend asked me if I thought that sewage having travelled that distance would harm them I should say I did not think it would.

9325. Long before that period, would it not have ceased to be anything but water; would there be any appreciable pollution in sewage that had travelled, I would not say 1500 miles in running water, but 150 miles?—I am not really an authority upon the matter, and would prefer not to answer the question.

9326. I understood you to say to the Commission that it made no difference to your chloride of sodium calculations whether there were 10 or 20 grains of chlorine, as far as purposes of calculations were concerned, in the sewage; is that so?—Yes.

9327. Are you aware that chloride of sodium is taken as the test of the amount of pollution in sewage?—My calculations do not refer to pollution.

9328. Answer the question first, and explain afterwards. Are you aware that chloride of sodium found by a chemist in sewage is one of the tests he applies as to its polluting character?—Yes, in pure water, no doubt.

9329. In any water?—No; you cannot tell anything about sewage in sea-water from the chlorine.

9330. Supposing a sample of water is given to a chemist, and he finds 20 grains of chloride of sodium in one sample, and 10 in the other, would not the chemist say that there was double the quantity of polluting material in the one as compared with the other?—Yes, I suppose he would, in pure water.

9331. In any water?—No; any sea water would upset that at once.

9332. Taking any two samples, and supposing that it is a question of pollution or non-pollution of water, and a chemist finds in one 10 grains of chlorine, and in the other 20 grains of chlorine, are you aware what the respective proportions of pollution would be in the two samples?—I do not understand chemical analysis the least in the world. I take it that the quantity of chlorine gives us the proportion of salt in the sample, and that is quite enough for this purpose.

9333. It makes no difference, whether you assume, as the basis of your calculation, that sewage contains 10 parts or 20 parts of chlorine?—I told you how much difference it did make for these calculations, namely, about one-half per mil.

9334. If sewage contained double the strength in one case that it did in the other, it would make no more than that minute difference in your calculations?—As far as progress is concerned.

9335. As far as anything is concerned?—No; I have not dealt with the burning up at all.

9336. Do you doubt that from the very first moment the sewage passes into fresh water it undergoes decomposition?—I do not doubt that, but I do not know anything about the degree.

9337. Do I understand that your tables merely put in a diagrammatic form the figures which have been given us by Mr. Mansergh and Mr. Latham?—Not exactly. These diagrams are based upon the actual quantity of rain-water which comes into the river on every day. Mr. Mansergh and Mr. Latham, as I said yesterday, have much greater experience than I have, and they have arrived by an average and a few figures at very nearly the same figure as I have arrived at by going into it in great detail.

9338. What is the principle they have taken in estimating the quantity of upland water with respect to the quantity coming over Teddington Weir?—They have taken all the tributaries.

9339. In taking the quantity of fresh or upland water coming into the River Thames upon the 14th of September, what water did they take as passing over Teddington Weir; was it the water of that particular day?—I do not know at all; I believe it was.

9340. What have you taken?—I have taken as near as I could the quantity of water which reached these particular places upon these particular days.

9341. Is that the same thing?—No; but it would make no difference at all (and I will tell you why) in arriving at the column. The great problem is to arrive at the size of the column, and any little error in the quantity of fresh water would only make an error of the same kind as the difference between 10 and 20 parts of chlorine makes in the analysis of the water.

9342. Supposing that there had been for 10 days what I will call an ascending cone of 100,000,000 cubic feet upon the 1st of September, and increasing until it comes to 200,000,000 upon the 10th of that month, and then a descending cone of 200,000,000 going down again to 100,000,000 cubic feet coming down over Teddington Weir upon the 20th; will you explain to me what they would have done, and what you would do?—They have first of all arrived at the column of fresh water as I have done, as shown by the white streak in the centre of the blue. Then assuming the water for the last month were the same as we find to-day, I think they say, it will be 34 or 35 days. I, on the other hand, say that it is not near enough; we shall have Mr. Michael or Mr. Bidder asking us about it. I will take the trouble to go into it and see what the actual flow was, and instead of taking the number of days due to the flow of the day, I have taken the number of days due to the flow of the past 30 days, and of course the number of days varies inversely as the flow. My flow, in some cases, was larger than their flow, and where it was larger I make the number of days smaller, and where my flow was smaller than their flow I make the number of days larger.

9343. Did you hear what Mr. Latham said, that if 200,000,000 was passing over Teddington Weir, it was an impulse communicated immediately to where the fresh water impinged upon the salt; that is 200,000,000 impinging upon the salt water 12 days before you have calculated it; if there is a difference of two to one millions you have taken some means between the two?—If Mr. Latham puts in the double quantity, he is right in saying that a double quantity will come out at Southend.

9344. Upon the same day?—Yes, but not of fresh water; of salt water; that makes all the difference. Every million of water you put in at Teddington prevents a corresponding quantity of water coming in at Southend; that is what Mr. Latham meant, and what he said.

9345. Will you take the 14th of September 1882 in the First Division, and show the Commission the mode you have adopted in order to test the quantity which Mr. Mansergh gives for the same day. I ought to say that yours is an intermediate period between high and low water; is not that so?—Yes, certainly.

9346. And Mr. Mansergh's is in one case high water and in the other low water?—Yes.

9347. The mean between the two will therefore make it correspond with yours?—Yes.

9348. Just work out one single division, and show whether or no a corresponding result has been obtained by you to the figures given by Mr. Mansergh; take

the first division below Crossness?—Take the sewage of the 16th of August.

9349. Would you begin by working out the Crossness division to correspond with Mr. Mansergh's of the same day, in order to see whether the results obtained by you are the same. I will only trouble you with one. We must take a fifth, in the first place, of 171,800,000, must we not? Taking Mr. Mansergh's table, upon the 14th of September 1882, at absolute high water, Division 7, "Quantity of upland water and sewage in each division"; the first division below Crossness I am going to take as the test. The figure is 1,112,518,704; then, if we turn to the next, which is low water, it is 798,899,651, adding those together, and dividing them by 2, will give you your mean quantity, or ought to?—That is, the mean between 800,000,000 and 1,100,000,000, which is, roughly speaking, 950,000,000.

9350. Would you kindly work out your own division, and see whether I have adopted the right plan in doing so. I would ask his Lordship to turn to the witness's diagram.

(*Mr. Lumley Smith.*) That would give you a mean of five miles; is the witness's five miles?

(*Mr. Michael.*) Yes. I am going to make them correspond to the five miles below Crossness; that is what you have taken from Mr. Mansergh, and I am going to take five miles from you. I take a fifth of your division, which represents the first division below Crossness, which comes to 171,800,000.

(*The witness scaled upon the plan.*)

9351. First take a fifth of your 171,800,000, then take your 164,964,940, then your 177,517,622, and your next four divisions, and then a fifth of your 161,455,422?—I make it something under 900,000,000; what do you make it?

(*Mr. Michael.*) 843,000,000 in round numbers.

(*Chairman.*) Do you correspond?

(*Mr. Michael.*) No; I make it that there is about 100,000,000 difference between us.

(*Mr. Lumley Smith.*) A little difference will arise from the same high water not having been taken. The witness's high water has been taken from a synchronous line, and Mr. Mansergh's has been taken from the absolute high water.

9352. (*Mr. Michael.*) Let me make it quite clear. To make the divisions correspond take one fifth of your 171,800,000, which is equal to 34,360,000; then your next division, 164,964,940; then the next, 177,517,622; then the next, 140,358,034; then the next, also 140,358,034; the next, 153,965,806; and then one fifth of the next division of 161,455,422, which is equal to 32,291,084, making a total, as against 955,000,000, of 843,815,520?—I should mention to you that it is very likely you have hit upon a division which has not been calculated, because every one of the daily divisions has not been calculated.

(*Chairman.*) As I catch it there is a difference of between 11 and 12 per cent.

(*Mr. Michael.*) Yes, of 12½ per cent.

(*Witness.*) But there is another very good reason for a discrepancy between us in these upper reaches of the river. Although the total column and the total number of days is exactly right there may be a considerable discrepancy between Mr. Mansergh, Mr. Latham, and myself at the Barking end for this reason: we are dealing with a column, and the whole of these calculations are based upon the measurement of a column; therefore it was necessary to take the dimensions of the column synchronously at the different points, and we have taken the dimensions of that column at high water at Southend, and at low water at Southend, and that would be half an hour before high water and low water at Erith, and more than that before high water and low water at Barking.

9353. (*Mr. Michael.*) How much difference do you say the difference between synchronous and absolute high water would make; would it make more than 1 per cent.?—I should think that is probably the error, because the whole thing is exactly the same.

9354. I will not allow that to stand in the way. I will take the fifth, making 803,000,000 against 965,000,000, or a difference of 160,000,000; however, I have sufficiently directed your attention to that?—It is very probable that the same points have not been taken at Crossness.

(*Sir Benson Maxwell.*) Was not the difference between the two in the last case in the other direction?

(*Mr. Michael.*) No, it is the same; in the first division it was 843 against 955, and in the next division it was 803 against 965.

(*Witness.*) But that is a discrepancy between what has been arrived at in an off-hand way and what has been arrived at by going into the matter in the fullest details.

(*Sir Benson Maxwell.*) Do I understand you to say that the difference of 20 per cent. between Mr. Mansergh's figures and yours makes no appreciable difference in the calculation?

(*Chairman to Mr. Michael.*) Suppose we take them to be wrong to the extent to which you wish to make them wrong, what effect would it have upon our judgment afterwards?

(*Mr. Michael.*) I cannot tell what effect the whole of these chlorine determinations may have upon your judgment.

(*Chairman.*) The whole of the evidence which has been given hitherto by the scientific witnesses is for the purpose of showing what will be or ought to be the condition of the river according to their speculations. They may be considerably wrong; they may be wrong 25 per cent., either one way or the other; but then in addition to that we shall have to consider the evidence which has been given by people who say that you can see it and smell it, and, if you please, taste it and touch it; that it is evident to all the senses. Then when you put those two things together, supposing that were made out, would it matter that some of these gentlemen are wrong 10 or 12 per cent. in their speculations as to what ought to be the state of things?

(*Mr. Michael.*) I imagine it would, unless you are going to judge by the evidence of non-scientific persons as to the effect of sewage being poured into water.

(*Chairman.*) If you were going to drink a glass of the water, it might perhaps make a difference whether it was 1 per mil or 1½ per mil.

(*Mr. Michael.*) It is a very important matter when you come to consider that sewage is directed by Act of Parliament to be poured into the river, whether it is poured directly into the water and remains there, and other local circumstances.

(*Witness.*) Another difference between Mr. Mansergh and myself is that I have interpolated the proportions absolutely in a descending line from the percentage at Southend to the percentage at the next point. Mr. Mansergh has done it in blocks, so that one of his blocks may be a little bit more than I make it, and the other a little bit less; by taking out isolated blocks you may find one a little more and one a little less, but the total column agrees within 1 per cent.

(*Mr. Michael.*) Do not say that, because I can give you the totals if you prefer. I cannot ask the Committee to give the time to go through the whole of the calculations, because they have already taken a very long time, but I venture to put it to you that there is a difference very much larger than that, that there is a difference of 10 per cent. between the totals at which we have arrived.

(*Sir John Coode.*) Between which points?

9355. (*Mr. Michael.*) Between Barking and Southend. I have worked out the quantity of upland water and the proportion of sewage to upland water. I say that there is a difference of 10 per cent. between the results arrived at by the two modes adopted?—I should like to go into this matter, for I think it is capable of explanation.

(*Chairman.*) It would be better if it would take you any time to work out the answer to Mr. Michael's

*Mr. R. W. P. Birch, M.Inst. C.E.*

14 Feb. 1883.

question, and he would be content if you would come another time and answer it.

*Mr. Michael* agreed to the suggestion.

(*Mr. Lumley Smith.*) If my learned friend has the calculation, I do not know whether he would let the witness have it and see whether it is correct.

9356. (*Mr. Michael.*) They are merely addition sums which the witness has to do of the totals arrived at by Mr. Mansergh and himself; it is simply the addition of the columns of figures and the deduction of the percentage. (*To the witness.*) Now, would you kindly tell me when you commenced to be in the steamboat "Toby" on the river?—In the middle of September.

9357. And you remained on board that boat for about two months, did you not?—Yes.

9358. Day and night?—Yes.

9359. In all parts of the river?—In all parts of the river below London.

9360. What are the points between which you ranged?—We could not go under the bridges.

9361. Then you had the general supervision, as I understand, of the men employed about the floats?—I had.

9362. I want to ask you one or two questions; I shall be as short as I can. Who was in charge of the floats on October 16th?—I should think I probably was.

9363. I will give you exactly the one float I want to know; the one that was driving up Erith Reach upon the 16th October. Could you tell me the name of the person who was in charge of the float at 1 p.m.?—Do you mean the waterman's name?

9364. Yes?—I can ascertain it.

9365. On October 17th you had two men called Meares and Whiting?—Probably. I know those names.

9366. Were they in charge of the float at Charlton at 6.15 in the morning?—I do not know offhand, but I will have it ascertained.

9367. I will go over the times at which we want the information, and you can give us the particulars afterwards. On October 16th, I want to know who were in charge of Float No. 6; they were near Millwall Pier. On October 29th had you two men called Tanner and Long at 5.50 a.m. On October 30th had you two men named Taylor and Clements employed at 5.17 a.m.?—I know those names. I do not know whether they were on duty or not; if you will give me the charges, I will have them answered.

The *Chairman* suggested that a list should be made out and supplied to the witness.

9368. (*Mr. Michael to the witness.*) Will you kindly give me the points at which the chlorine determinations were made, and the times?—I cannot speak from my own knowledge about this matter, but someone is coming who will be able to tell you. I take it that they were taken at St. Paul's Pier, Deptford, Barking, Crossness, Erith, Gravesend, and Southend, at high and low water.

9369. At what dates?—The 14th and 22nd of September and on the 30th of November.

9370. The chlorine determinations were taken upon three occasions at those various places?—Yes.

9371. (*Sir Benson Maxwell.*) Did you see them taken?—No, I have used the information which was sent to me.

9372. Do you know of your own knowledge what part of the stream they were taken at; were they in mid-stream?—I understand that each sample was composed of numerous samples taken at various places across the stream at various depths.

9373. (*Mr. Lumley Smith.*) We have it in Mr. Latham's evidence that the chlorine samples were taken by taking samples of the water at different places across the river and mixing them up.

(*Sir Benson Maxwell.*) That was stated by a person who had only a general knowledge of the matter, and not a personal knowledge. Mr. Latham had the general supervision, and it was reported to him that they were so taken.

(*Mr. Michael.*) I was under the impression that Mr. Birch had the general supervision.

(*Witness.*) In using them, I have taken them as mean samples of the water of the whole of the cross section of the river.

(*Mr. Lumley Smith.*) We shall be able to tell you where the specimens were taken for the purpose of the tests.

(*Sir John Coode.*) When, where, and how?

(*Mr. Lumley Smith.*) As Mr. Birch is coming back again, I venture to think it might be advisable to postpone his re-examination entirely.

The witness withdrew.

Professor William Cawthorne Unwin examined.

*Prof. W. C. Unwin.*

9373. (*Mr. Lumley Smith.*) You are a member of the Institution of Civil Engineers?—I am.

9374. And you are Professor of Hydraulic and Mechanical Engineering at the Royal Indian Engineering College at Cooper's Hill?—I am.

9375. I wish to ask you a few questions upon the subject matter of our inquiry. First of all upon your opinion as to how far the movement of sewage in the river is a question of hydraulics. The sewage, as we know, gets into the river first of all—that we may take for granted—it gets from the sewers and the outfalls into the river; does it all remain there, or are there any influences at work which would get rid of some or any of it. I will ask you that before we come to consider the question of hydraulics, where it will get to?—There seems to me to be only two ways in which the volume of sewage discharged into the river can disappear from the river, and so escape, being considered a matter of hydraulics. The sewage may decompose into gas which escapes into the air, but I think the volume which escapes in that way must be very small. Part of the sewage may be deposited upon the bed of the river, and that no longer forms part of the flow of the river; but there are no means of ascertaining what proportion of the sewage disappears in that way, only I suppose it is then still in the river, and still liable to do injury to the river.

9376. If I may stop you for a moment, a portion may pass out in the form of gas into the air; that, you think, would not be a matter of much importance as it would not be a large amount?—So I think.

9377. A portion would go to the bottom of the river—that is a matter of hydraulics—there is no means of ascertaining what it is?—I know no means of ascertaining what it is.

9378. Then a portion would remain in the river, and you deal with that for the purpose of representing the sewage?—I do.

9379. Are you in a position to give any evidence with regard to the extent to which the sewage which remains in the river is noxious or innocuous?—I leave that question entirely to the chemists and biologists.

9380. For the purpose of your examination you treat the sewage which goes into the river as remaining in the river?—Yes.

9381. Now, going into the principles upon which the movement may be arrived at, we will deal with what would have been the case if this had been a non-tidal river. In the case of a non-tidal river what should we have to consider as the movement?—The principle we must have recourse to is that the quantity of water between two sections remains constant, so that, for any given period, the quantity which flows in at one end is equal to the quantity which flows out at the other.

9382. That is a very simple question; you take two cross sections of the river, and what flows in at one will flow out at the other, assuming that the

section is the same?—Yes, but there is this point to remember, that if the river is carrying different materials, such as river water, sea water, and sewage, then the quantity of each of those materials which flows in at one end must be equal to the quantity of each of those materials which flows out at the other.

9383. That is to say, if the quantity of each which goes in at one end is equal, there would be an equal quantity of each flowing out at the other?—Yes.

9384. Each keeps the same ratio?—Yes; that would have to be assumed in the calculation.

9385. Now, coming to the case of a tidal river, does that alter very much the condition of what passes out?—The volume between any two sections is constantly changing.

9386. What does it change with?—With the height of the tide; but if we neglect the alteration from day to day of the range of the tide, then at corresponding phases of the tide the volume between two sections is the same.

9387. Taking the same height upon different days, you always get the same quantity between two cross sections, that seems simple also, and that applies equally I presume, subject to anything that comes from mixing to the component parts of the fluid?—Quite so.

9388. Now will you proceed with regard to what takes place at each particular section of the river, taking the volume of the flow of the different sections of the river, and beginning at the uppermost end of the reach of the tide. Taking it at Teddington you get coming in the water over Teddington Weir?—At Teddington there flows in a volume of upland water, and on the principle that I have just stated the volume of flow in the period of a tide, across every section of the river, must be exactly equal to the volume of the upland water, with the exceptions which I have to make presently. The down stream displacement at every section of the river must therefore be, in each tide, the volume of the upland water divided by the area of the section.

9389. You know what comes in at Teddington, and that quantity must pass every section of the river. As you go down the river the same number of gallons as come over Teddington Weir will be displaced, of course, at any particular section of the river in the course of a day, whether the whole goes through or not, will depend on the size of the section, it will be affected by the size of the cross section?—The same volume flows across every section.

9390. Then it is the velocity that would vary?—The displacement will vary with the area of the section.

9391. Of course by displacement you do not mean the mere oscillation of the tide, but merely that the water is pushed further down the river?—The displacement due to the upland water alone.

9392. You said an exception would have to be made—is there any general cause which modifies what you have been saying?—In the oscillating flow of the tide there are generally local currents and other differential motions of different portions of the water; the effect of that is that some portions of the water are carried further up stream during the flow of the tide, than other portions. That resultant motion is not altered, because if one portion has gone further up stream, another portion must have gone less far up stream. During the ebb, some portions of water are carried down stream further than other portions. The resultant motion of the river is not altered, but when there are supplied to the river, different materials, at different points, this differential motion tends to distribute them in quite a different way from what they would be distributed in, if there were none of these local currents or differential motions.

9393. Take sea water for example; if the whole sea water came up *en masse* and kept altogether, it would go back again in the same way; but you say that in consequence of the currents and other local causes, some portions of the sea water would make a shoot and go further up the river than the general mass?—Yes.

9394. So in going down, portions of water so coming down shoot out beyond the main mass, and the consequence is that there is mixing going on over and above what would be expected but for these differential causes?—That is so.

9395. The result is, that you do find, or would be likely to find up the river, portions of what had come from below, further up the river than the main masses which have gone back?—Yes.

9396. Now will you apply that to the river above Crossness?—Taking the river above Crossness the water is fouler as we go down stream. Now, during the flow of any one tide, part of the foul Crossness water is carried up stream a distance greater than the mean tidal range and mixes with water which was previously at a higher point in the river.

9397. Putting that into simple language the mean tidal range takes up the water from below Crossness a certain distance, and portions of it are stirred up in eddies and mixed with the water above?—Yes.

9398. As the result of that, you have found foul water from below Crossness higher up than you otherwise would?—Quite so.

9399. Now take the case of the ebb; when the tide begins to ebb again what happens to that water which has been so carried up the river?—The water which has been carried up the river gets mixed with the whole volume of water in that part of the river where it is. During the ebb part of that goes down again, but part of the foul water is left behind mixed with the low water volume, so that at the end of the ebb there is a portion of foul Crossness water at a higher place in the stream than it originally was before the tide.

9400. Then after the first flow and ebb, a portion of the foul water has been displaced relatively to the rest of the water, so as to be higher up the river?—Yes, quite so; a portion of the Crossness water has gone up stream.

9401. Is that, according to the process you have been describing, likely or possible to be repeated in subsequent tides?—It must be repeated upon every tide.

9402. Then what would be the result upon the foul water?—The result is that, in the low water volume above Crossness, you have a portion of the Crossness water distributed in every portion of the river from Crossness up to Teddington. There is in the low water volume a portion of water which has come up from Crossness.

9403. (*Chairman.*) Will you allow me to ask you this—is this the result of observation or speculation upon the river?—I assume we know that in all rivers portions of the water move faster than other portions—assuming that, then what I have said must follow.

9404. Then it is the result of speculation?—Yes.

9405. If it were a perfectly straight cut like the Dee at Chester, I suppose your observation would not be true?—On the contrary, it would be quite true there.

9406. Would there be any eddy or current there?—In the straightest reach the central or surface portions move about 15 per cent. faster than the mean and about 25 per cent. faster than the bottom.

9407. Then that might make it applicable to the straightest possible navigable channel?—It is a principle applicable to all streams.

9408. (*Mr. Lumley Smith.*) Would that principle apply to a winding river like the Thames—would the local causes apply equally to, or in a greater degree than, where there was a straight cut?—It is a little difficult to say—probably you have more local currents in a winding river than in a straight reach.

9409. Then according to your theory in respect to this, the foul water from Crossness might work up the river to what points?—Either to Teddington or to a point not more distant from Teddington than the upland water displacement in the period of a tide.

9410. Close up to Teddington the upland water

*Prof. W. C. Unwin.*

14 Feb. 1883.

would drive it back and prevent it getting up?—Yes.

9411. Does the same principle apply to the pure water going down stream?—In the part of the river below Crossness, the effect of the mixing action is to make the Crossness water go down stream quicker than it otherwise would—the portion of the Crossness water which so goes down stream is balanced by the portion of sea water which comes up to Crossness.

9412. I suppose upon the same principle with the water below Crossness, which is what we will call four water, when any foul water gets higher up than the mean, a certain quantity of pure water must go lower down than the mean in order to fill its place?—Yes, quite so.

9413. So that the quantity is the same, but does the alteration of the pace of travelling or displacement of the water have any effect?—In a river entirely of fresh water it would have no practical effect, in a river consisting of different materials it has the effect of distributing all those materials over the whole length of the river.

9414. Then the practical result is that the distribution goes on over the whole of the river, and it is not confined to what would go on below Crossness?—Below Crossness sea water travels up stream, and the Crossness water travels down stream.

9415. What is the effect then of this mixing on the escape of the foul water from Crossness? You have told us that some of the Crossness water would go up stream, does the mixing make the foul water go to the sea faster or less fast than it would?—Below Crossness the foul water gets down to the sea much faster than it would if there were none of this mixing.

9416. Take the case of the tide coming into the river at Southend, have you taken any figures as representing what comes into the river at Southend during the flow of a spring tide?—During the flow of a spring tide something like 24,400,000,000 cubic feet of sea water flow into the river.

9417. And that, as I suppose, goes out with the ebb?—It mingles with some of the foul water up stream and carries back part of it to the sea.

9418. It takes up some sewage and I suppose leaves sea water behind?—It leaves some sea water behind.

9419. Taking another hypothetical case which I think my learned friend Mr. Bidder suggested, of an estuary; supposing the Thames had no supply of upland water, what would be the effect upon the sewage at Crossness?—If the Thames were an arm of the sea and had no supply of upland water, then, apart from the mixing action, it would gradually fill up with the sewage; but, in consequence of the mixing action, the sewage would still travel out to sea at a pace quite considerable. I could not say in what proportion to its present pace, but it would still travel out to sea, a portion of the sewage being taken out to sea in every tide, mingled with the tidal water, and a portion of the sea water which had come up, being left behind in the low water volume.

9420. By degrees the sewage mixed with the water in the estuary would get out to sea as in summer?—Yes, that is so.

9421. With regard to the actual condition of the river, that, as I understand from you, is affected by this mixing action which goes on between the tidal water and the low water volume, which we may take as coming from the upland?—Yes.

9422. (*Chairman.*) I suppose on account of the influences you have spoken of where sea water has got to a higher point than where it started from, the mixture might go up to the very top of the estuary?—It must go up to the tidal limit, except the distance occupied by the quantity of upland water that comes in during one ebb.

9423. I was supposing there was none, that was the case you put?—Then it must go right to the top.

9424. There would be a mixing right to the top, you think?—Yes, there would be a mixing right to the top.

9425. Even if it were a narrow estuary, if one can make use of such an expression, the effect would still be the same?—I say it must go to the top. I am not speaking of the quantity, the curve may be asymptotic, it may become excessively small.

9426. (*Mr. Lumley Smith.*) Of course the extent to which sewage comes up the river is a matter of degree according to your theory, the extent to which it would come up the river would depend partly upon the position of the outfalls and matters of that kind?—Quite so.

9427. We are aware that the legislature have said that the drainage of London shall be carried so far as not to come within the metropolitan area, you are aware of that?—I see it is stated very strongly in the debates in Parliament.

9428. It is stated also, I think, in the Act of Parliament; you have some references, I think, with regard to what the objects were, will you tell us very shortly what they were in the first place? I think the amending Act threw the whole burden upon the Metropolitan Board of Works, leaving them a discretion as to what should be done?—I have before me a reference to the Parliamentary debate, it will, perhaps, be taken as admitted that it was assumed that sewage should not be permitted to flow back into the Metropolitan area.

(*Chairman.*) We must look at the Act itself.

(*Mr. Lumley Smith.*) But your Lordship would know that we may gather what that Act meant by what took place when the Act passed.

(*Chairman.*) I think you are right that if it was evidently intended that the sewage was not to come to a particular place and we were instructed that it did, we might receive that evidence, although the Act did not say in distinct terms that it should not, but the witness cannot tell us what took place in Parliament as an expert.

9429. (*Mr. Lumley Smith to the witness.*) You think, in point of fact, that with the outfalls where they are, theoretically the sewage comes back or would come back?—Part of the sewage flows back through the whole range of the metropolitan district.

9430. Now I will ask you another question which seems to lie upon the surface; would the theory apply equally although the outfalls had been further down the river?—It would still apply. I have calculated, and will give you directly what would happen if the sewage were discharged at Gravesend.

9431. (*Chairman.*) The witness gave a guarded answer, or rather you put a guarded question. Is there a sensible quantity of sewage in the river up as high as Chiswick?—That is very close to the tidal limit, it just disappears at Chiswick.

9432. We will take Vauxhall Bridge—I am going to show you the actual quantities directly.

(*Mr. Michael.*) I ought to state that I had intended to direct Mr. Birch's attention to the fact that Mr. Mansergh's table assumes in the second division 15 per cent. throughout, it is an assumption upon his part of that certain quantity constantly. I put these figures to Mr. Birch for the purpose when he calculates it out, of showing that the percentages are very different from the one which is here assumed.

(*Chairman.*) I should like to hear what Mr. Unwin has now to say upon this point.

9433. (*Mr. Lumley Smith.*) I do not see how that bears upon Professor Unwin's examination at the moment, but I dare say it does. (*To the witness.*) Now will you just tell us your process, you have prepared some diagrams and tables, have you not?—I have. (*A set of diagrams and 13 tables were handed in; see Appendix A E, 1 to 21.*)

9434. Will you explain to the Committee, as you can do it better than I can put it to you, the mode in which you proceeded?—Data have been supplied to me of three tides during which observations were taken.

9435. What are the dates of those?—September the 14th and 22nd, and November the 30th.

9436. On those days there were supplied to you

certain elements for consideration, just tell us what those were?—From Professor Way I have received chlorine analyses of the water at 10 stations on the river.

9437. I think we may as well catalogue those stations as we go along?—Teddington, Chiswick, St. Paul's Pier, Deptford, North Woolwich, Barking, Crossness, Erith, Gravesend, and Southend.

9438. You had from Professor Way chlorine analyses of the high water found at those places?—Yes, both high and low water. From Mr. Mansergh I had computed sections of the river at high water, and at low water.

9439. At what places?—The same places.

9440. Those are the sections of the river?—Yes, those are the sections of the river, those sections being computed for absolute high water.

9441. When you say absolute "high water" you mean absolute high water, and absolute low water too?—Absolute high water and absolute low water; that is at the high water and low water at each place. From Mr. Baldwin Latham I have received gaugings of the water coming past at Teddington, and the water coming into the river from the tributary streams.

9442. As I understand you have got the water that comes over Teddington Weir; you have got the sectional area at ten places on the river, and you have got the chlorine analyses at those ten places?—Yes.

9443. Now will you tell us what you proceeded to do?—First of all, I proceeded to find the length of the horizontal oscillation of the tidal current.

9444. How did you do that?—I have computed the volumes of water in the river above each of the sections at high and low water, and perhaps I can make it plainest if I refer to a specific case. I am going to refer to Table 2, the column of total volumes. On September the 14th there were 10,474 cubic feet above Saint Paul's Pier at high water; there was almost exactly the same quantity above North Woolwich at low water. I say that the horizontal oscillation of the tide at those places was from North Woolwich to St. Paul's Pier.

9445. You found as much water at low water at one place as at high at the other?—Yes, the volume which occupied the river above St. Paul's Pier at high water extended to North Woolwich at low water, that gives the horizontal oscillation of the tide. Now, proceeding on that principle I have drawn diagram No. 1, which gives the horizontal oscillation of the tide for two tides, a spring tide, and a neap tide.

9446. (*Chairman.*) I do not know whether the other side will agree to that. I do not see because there are 10,474 feet at St. Paul's Pier at high water, and 10,210 at North Woolwich at low water, how that shows the oscillation of the tide. It may do so for aught I know, but I do not see why it should?—The water which occupied the space of the river above St. Paul's Pier at high water would just fill the river down to North Woolwich at low water. Then the resultant oscillation of any particle would be that distance, for if some particles went more, others must have gone less. The mean motion must have been through that distance.

9447. (*Mr. Lumley Smith.*) Are you putting out of consideration any water coming over Teddington Weir at the time?—I am treating it as a tidal question alone for the moment; we are treating it as a matter of tidal oscillation.

9448. Would it not be better to say that if you find the quantity of water at low water at one place is the same at high water at another place, that would come to the same thing?—It would come to the same thing.

9449. (*Mr. Michael.*) Do I understand that the tables are calculated without the upland water, and that the diagram is calculated with the upland water?—No; they are calculated upon the same basis. I am going to consider the displacement due to the upland water separately; it is more convenient to separate the motion of the water in the river into two components. There is a down stream motion due to water coming in at Teddington, and there is the movement due to the influx and reflux of the tide.

9450. (*Mr. Lumley Smith.*) Therefore now you are taking the motion of the tide regardless of the water coming in over Teddington Weir?—That is so.

9451. Will you now proceed with your explanation?—I have plotted the volumes in curves, and the horizontal intercept between the volume curves for high and low water shows the mean horizontal range of the tidal current. The horizontal intercept between the high water or the low water volume lines, shews the displacement due to the change of the tidal height. (*The witness explained his diagram to the Commission.*)

9452. (*Chairman.*) At low water at North Woolwich there was the same body of water as had been at high water at St. Paul's Pier?—Yes.

9453. Therefore it looks as if you supposed, though I know you do not suppose it, that the whole of the water at North Woolwich had gone away, and had its place supplied by what was formerly above Deptford, but that is not what you mean?—If you put a diaphragm across the river at North Woolwich at low tide, and allow the tide to shove that up the river, it would come at high tide to St. Paul's Pier, and you would have the same volume in the river above it, as you had down to North Woolwich at low water, without the diaphragm.

9454. (*Mr. Lumley Smith.*) You have taken the mean tidal oscillation?—Yes.

9455. There are corresponding curves for September the 14th and 22nd?—Yes, for the spring tide and the neap tide.

9456. The horizontal lines which are drawn between the high and low water curves represent the oscillation between the two places?—Yes.

9457. (*Chairman.*) Of course with regard to oscillation, you do not mean that if anything floating had been put in above Deptford pier at high water it would not have gone further down the river than North Woolwich in the course of a tide, do you?—If you exclude the action of the upland water for the present, then a floating body which had the mean motion of the water would go that distance; some floating bodies would go further, and some would go less, but the mean of the whole series would be that.

9458. What is the distance between the two places, not much more than four miles, is it?—I can now refer you to Table 3, where the horizontal oscillations are given in miles measured off the diagram.

9459. But the tide runs through it two or three miles an hour either way, does it not?—Yes, at the height of the tide, but it begins at nothing, and goes up to the maximum, and goes down to nothing again.

(*Mr. Lumley Smith.*) That is the tidal wave that runs up, but not the actual water.

(*Witness.*) At the maximum the velocity is perhaps three miles an hour, but the mean is very much less than that; it begins at nothing as I have said, and goes down to nothing again.

9460. (*Chairman.*) I thought we had had it proved before us that a thing will float up or down about 12 miles on a tide?—A float travels 12 miles, and therefore it appears that 12 miles is the range of the tidal oscillation; the only objection to that is that the floats are in the tideway and near the surface, and move a little faster than the mean motion. My tidal oscillation at the points where the floats were is a little short of 11 miles in a spring tide and 7 miles in a neap tide.

9461. (*Mr. Lumley Smith.*) That is shown in your Table 3?—Yes, in Table 3. I should like to put it shortly that the tidal ranges I got are shorter than those observed by Mr. Latham, the difference being due to the fact that Mr. Latham's floats gave the motion of the central and surface parts of the water, and not exactly the mean motion of the water.

*Prof. W. C. Unwin.*

14 Feb. 1883.

9462. Would this diagram be affected much by what you would call the disturbance owing to differential causes, eddies and so on?—It does not affect this diagram in the least, if it is understood to mean the mean of the motion of the particles, because for every lb. of water that is carried up stream by the mixing action a lb. of water is carried down stream by the mixing action, so the resultant is nothing.

9463. Now with regard to your Table 3, have you any further remarks to make?—Upon precisely the same principle I have calculated the horizontal displacement due to the variation of the tidal range from day to day. I found the amount of displacement due to the variation of the tidal range between the 14th of September and the 22nd of September, and I have given it in one of the columns of that table to compare with the tidal ranges; and it will be seen that the alteration of the height of the tide between those dates gives a considerable displacement, which is also shown by Mr. Latham's floats.

9464. I do not quite follow you as to why that shows horizontal displacement. I suppose that means displacement up and down the river?—From September the 14th to the 22nd the tides were decreasing from spring tides to neap tides, and during that time there was a displacement up stream by the number of feet given in that column, varying from 3,000 feet at Chiswick to 12,000 feet at Southend. When the tides again increased from neap to spring tides there would be a displacement down stream of the same amount.

9465. What are the feet in that column; they are horizontal feet, are they not?—Yes, they are horizontal feet. Supposing there had been no upland water the float would have been found, say at Barking, 9,000 feet upon the 22nd above where it was put in upon the 14th at the same stage of the tide.

9466. It is the horizontal feet opposite those places that you are referring to, is it not?—Yes.

9467. Is this horizontal displacement a displacement of the water?—The mean displacement of the particles of water at the section at the place which I named. For instance, the particles of the water at the North Woolwich section will be displaced up stream 9,300 feet between the 14th and 22nd by the alteration of the height of the tide; that is apart from any further action there would be of the upland water pushing them down.

9468. The next column gives the "increase of the low water volume"; what do you deduce from that?—That increase of low water volume is the increase of volume which has gone up stream and been left there in consequence of decreased range of tide That I put down to show that that is one of the causes that carries water up stream. As the tidal range diminishes a larger proportion of water is left behind in the low water volume.

9469. Now with reference to your first diagram; is that to scale?—The diagram is to scale, and the results measured from it are given in Table 3.

9470. Is there more than one scale on diagram 1?—The first half of the diagram is a vertical scale, 10 times as great as the latter half; the two scales are given on the diagram; the vertical scale is 10 times as great for the first half as for the second.

9471. (*Sir John Coode.*) These figures upon the horizontal lines represent, I suppose, distances in feet?—They do.

9472. (*Mr. Lumley Smith.*) You have finished with No. 1, now what is diagram No. 2?—I prepared diagram 2 in order to get a clear notion of the volume of upland water flowing in the river upon the three days for which I have made calculations. The ordinates of those lines are the volume of water flowing at each point along the length of the river; you begin with the volume flowing at Teddington, then there is a tributary, and you get a little more at Chiswick; above Deptford there is a tributary, then you get a little increase till you come to Barking, and there I have added in the sewage discharged, and at Crossness I have added the sewage discharged there, and so I have gone on.

9473. By fresh water you mean what is non-sea water, but includes sewage?—I mean the flow from Teddington, from the tributaries and from the sewers.

9474. When you get to Barking the first flow of sewage comes in?—Yes.

9475. Am I right in saying that this represents the comparative portion of the water at each part of the river which is not sea water?—Yes, the volume of fresh water, including sewage.

9476. It is not the amount of fresh water that is in the river, but of what comes in at each particular place?—Yes, the principal importance of the diagram is to show how very small an influence the tributaries have, except the two affluents at Crossness and Barking. At Crossness and Barking the flow is increased considerably.

9477. (*Sir John Coode.*) I should like to ask why the volume of sewage was so much less upon the 14th and 22nd of September, taking Barking more particularly, than upon the 30th of November?—There is a tributary there, which is added in as well as the sewage, and that tributary was flowing largely upon that day. I have taken the gaugings from Mr. Latham's tables. There are some tributaries which come in, the Lea especially, between Barking and Deptford.

9478. What strikes one is that the volume of sewage should not vary very much, but, if you take the 14th of September it is only one-half what it was upon the 30th of November?—I have taken the sewage at the same all round, but the difference is due to the flow of one of the tributaries.

9479. (*Mr. Michael.*) May I ask where you have put the River Lea?—I have taken all the tributaries, which enter between two sections, as entering at the lower of the sections.

9480. Where is the River Lea coming in?—The River Lea comes in between Deptford and Barking; it forms part of the step which you see at Barking.

9481. Or of the five miles above?—Yes, quite so.

9482. (*Sir John Coode.*) I understand the witness to say that at each step he allows for the tributaries which have come in since the last step?—I have formed the judgment that that was the most accurate way of dealing with it for my purposes. If the tributaries were very large, compared with the flow at Teddington, I should have preferred some other method, but as the tributaries are small, compared with the flow at Teddington, it is sufficiently accurate to take those which come in between any two sections as coming in at the lower section.

9483. (*Mr. Lumley Smith.*) I suppose it follows, does it not, that ordinarily when there is flood in those tributaries there is flood in the Thames?—Very much so; not always, but generally.

9484. The relative amount is not so very much altered?—No.

9485. Now Diagram 4 goes with Diagram 2, does it not?—I think I should prefer to take Diagram 3 next; Diagram 3 shows the amount of displacement down stream at each section due to the upland water alone; that is neglecting the tidal oscillation. By dividing the volumes in Diagram 2 by the areas of the sections, we get the displacement down stream, which has occurred in the tide, in consequence of the water which came in at Teddington and the other tributaries.

9486. (*Sir John Coode.*) That is what would have taken place if there had been no tidal water, or is that the actual displacement?—If you take two periods of low water the effect of the tidal oscillation has disappeared. There has been a flow of the tide and an ebb of the tide, and that has left things as they were. Between low water and next low water there will have been a displacement down stream, because during the 12 hours period, there has been a flow of water coming in at Teddington. The amount

of displacement due to the water which has come in is shown in the curves.

9487. (*Sir P. Benson-Maxwell.*) Is that the volume which has come in?—No, the volume which has come in divided by the area of the section; and this gives you the displacement down stream, which is due to the upland water alone. Diagram 3 is calculated for September the 14th, when the quantity of water at Teddington was about the average quantity. I have not drawn a similar diagram for other days, because it was simply to give an idea as to the way in which the displacement due to the upland water is diminished as you go down stream.

9488. (*Mr. Lumley Smith.*) Diagram 3 is in miles per tide?—Yes, miles per tide.

9489. Then, taking it to Gravesend, it goes down to the fifth of a mile?—Yes, 0·2 miles.

9490. Then at Gravesend upon any particular tide the displacement due to the upland water would be a fifth of a mile?—Yes, per tide.

9491. By "tide" do you mean a complete tide, up and down?—By a tide in all my calculations I mean 12½ hours, or, to take it more exactly, 12 hours and 25 minutes.

9492. Then at Gravesend it would be about ⅖ths of a mile a day?—Yes, ⅖ths of a mile a day almost exactly.

9493. And so on for the other places?—Yes.

9494. That is due to upland water only. Now have you anything more to say upon Diagram 3?—These are the displacements which a float should show if the float really had the mean motion of the water.

9495. (*Sir John Coode.*) That is to say, that if there were no wind or no disturbance due to eddies or abnormal causes, the theoretical motion?—That is the motion the float ought to have if it were not disturbed by the wind, and, if it were, the average of a series of floats which occupied the whole width of the river.

9496. What we might call the mean motion of the whole volume?—Yes.

9497. (*Mr. Lumley Smith.*) I believe you have a note that "the mean displacement between Deptford and Erith is about ⅖ths of a mile per tide"?—Yes.

9498. Why did you take between Deptford and Erith?—I wanted to show what the displacement was for one place, and I took a place where the knowledge of the displacement was a little important.

9499. Have you looked to see whether the quantity of water coming over Teddington Weir was more or less than the mean on that day, the 14th September?—It was about an average quantity.

9500. Is that the only day that you have taken it for?—It is the only day I have made these calculations for.

9501. Upon days when less water was coming over, what alteration would you find in the displacement?—If the quantity of upland water were less, the displacement would be less, and if the quantity of upland water were greater, the displacement would be greater.

9502. Are you able to give my learned friend the formula by which he can calculate the amount of displacement, owing to the water coming over?—The displacement is directly as the volume.

9503. Before we pass from these tables, I wish to ask you this—you have taken the sewage that comes in at Barking and Crossness?—Yes.

9504. Where did you get it from?—I got it from page 17 of Mr. Latham's Report of the sewage flow for 1881, and that worked out to 13,603,000 cubic feet per tide, or 26,000,000 cubic feet per day.

9505. I want your view as to the value of the float experiments, and how far they coincide or do not coincide with what you would expect; first of all, I think you have told us this, but it will be convenient to have it grouped together. If the floats gave a mean down stream travel, they would agree with the diagram?—They would agree with the diagram.

9506. With which of your Tables?—With Table 5.

9507. Do you in fact find that the floats' travels, as shown by the diagram, which Mr. Latham has prepared, agree with what you have shown in Table 5?—The down stream travel of Mr. Latham's floats is very much smaller than it would be according to this diagram.

9508. By "travel," you do not mean travel by the oscillation of the tide, but taking the displacement of the water by other matters taken over a long period?—Yes.

9509. What is the reason why the floats are not displaced to the same extent as the mean volume of the water?—The floats were kept towards the middle of the stream, and the floats are too short to reach down into those layers of waters which move slowest. The floats therefore were in layers of water, which had a greater motion than the mean motion; they will travel over a greater range of horizontal oscillation in a tide, and they represent, not the real mean motion of the water, but the motion of those parts of the water which are towards the centre and towards the top.

9510. Now, first of all, with regard to the top, do you find as a rule that the top moves faster than the mean motion?—In all streams the surface has the greater motion.

9511. And also with regard to the centre?—The centre has a greater motion than the sides.

9512. Then the centre and the surface combined would produce a greater range than the mean motion; or, how is that?—The motion in the centre and at the surface would be considerably greater than the mean motion of the water.

9513. Is there a difference between the range of displacement of the flood and of the ebb; how do you account for the floats being displaced up the river, instead of being displaced down?—I should like to point out that in each tide a float travels a distance of over 24 miles; to take a fair average case it goes 12 miles up stream, and 12½ miles down stream. I am putting a case rather unfavourable to myself; its whole travel is therefore 24½ miles, but its displacement down stream is only half a mile. Now, if from any cause the velocity in the travel up stream is a little greater than it ought to be, or the velocity in the down stream is a little greater than it ought to be, that small alteration of velocity over the 12 miles travel will make a great alteration in the displacement. About four per cent. alteration of velocity up stream will diminish the down stream displacement to nothing; about four per cent. alteration in the down stream velocity would double the down stream displacement. To explain Mr. Baldwin Latham's results therefore, all we really have to do is, to find out whether there was possibly an alteration of something like four per cent. in the velocity of the float during its 12 mile travel up stream or down stream. The alteration in the displacement is very large, but that may be due to a very minute alteration in the velocity during its travel.

9514. You see, taking the 12 miles up and 12½ miles the other way, that makes 24½ miles as the whole motion of the float; and, if you take the ordinary displacement of the mean water at half a mile, its motion is 49 times the actual amount of displacement; therefore, you think that a little variation in the currents or in the velocity would far more than counterbalance that half mile?—Yes; a slight alteration in the velocity either in the up stream or down stream travel will make a great alteration in the tidal displacement.

9515. Is there any difference in the tidal wave or the currents produced by the tidal wave as you go up stream or down stream?—I see some reason to think that the ratio of the central and surface velocity to the mean velocity is greater during the flow of the tide than during the ebb of the tide—I think it is possible that there is quite 4 per cent. more central

*Prof. W. C. Unwin.*

14 Feb. 1883.

and surface velocity during the flow of the tide than during the ebb.

9516. I see that Mr. Baldwin Latham spoke of having seen you upon the subject and quoted your opinion at question 8451 as to the probability of the floats going up the river rather than down. I think he said that in your opinion the possibility was "that "in tidal water in going up the stream the water "obeys the law of the tidal wave, but in coming "down it flows off more generally as a flowing "stream. The consequence is that the velocity of "the tidal wave being very much greater in deep "water where the curve is sharper than it is in the "case of the ordinary flow down, where it is flatter, "the float in the middle of the river would have a "greater tendency to go up upon the tidal than it "would have to come down again upon the ordinary "flow"?—The flow of the tide is purely the phenomenon of a wave of translation propagated up stream and extinguished at the tidal limit. The flow is due to wave action. During ebb there is no wave action, and the water flows in consequence merely of its surface slope.

9517. Will that account for the progress sometimes made by the floats up the stream instead of being displaced by the main body of water down stream?—What I want to point out is that a very small alteration of velocity due to local currents, or any similar cause, will account for the floats behaving in an eccentric way. I think there is a general cause which has sent the floats up stream and that is that the ratio of the central and surface velocity to the mean velocity is greater during flow than ebb. I should like to mention at this point that I examined this morning some very careful current meter observations which were taken at Putney; that is not at all a good station for observing the fact, because it is too high up the river, but I do find there, that the upper portions of the water have a higher velocity in proportion to the mean during flow than during ebb. I can give the numbers if you desire it.

9518. At what parts of the river do you find these discrepancies in the floats?—The greatest discrepancies in the travel of the floats occur in the crooked portions of the river.

9519. Are you able to say whether in crooked parts of the river you find the water affected by the shape of the banks, and so on?—In crooked parts of the river some of the bottom water is brought up to the top—the whole stream twists upon itself and the ordinary ratio of the velocity of the central and the surface water to the mean velocity is very considerably altered. I do not know that that is the explanation, but it seems very probable that in the crooked portions of the river the travel of the floats would be different from what it would be in the straight portions of the river.

9520. Comparing for a moment the travel of the floats with what would be likely to be the travel of the sewage, what differences do you expect, do you think, that they would fairly represent that where a float went sewage might go; or, what other technical considerations do you think would affect the matter, with regard to eddies and so on; which do you think would be most likely to get highest?—The travel of the sewage would be identical with that of the floats, if there were nothing like mixing action; but the floats cannot partake of the eddying motions which mix up the water, and they get none of the travel which is due to the mixing action; the sewage travels faster than the floats, because in addition to the pushing down by the up stream water, it is pushed down by the sea water which is left in the low water volume after each tide.

9521. Now, with regard to the saltness of the river, I think my Lord asked you whether any of the saltness was found by the sewage. I believe you have told us that you got your materials from Professor Way?—Yes.

9522. Have you plotted out from the diagrams certain curves showing the saltness at different parts of the river?—No. 4 diagram shows the saltness furnished me by Professor Way, plotted in the form of curves for three tides.

9523. Your vertical scale shows the number of parts of chlorine in 100,000 parts?—Yes.

9524. You have also taken the quantity of chlorine in sea water as 1961 in 100,000 parts?—Yes, the sea water is shown just under the words "pure sea water" upon the right hand side of the diagram.

9525. It is not quite 2000?—It is not quite 2000.

9526. Then, comparing the saltness with pure sea water which is represented by the top dotted line, or the little black mark just under it; at Erith you seem to get at your ordinate about half the height of sea water?—About half on the high water of September the 14th.

9527. Upon the 14th of September at high water the water at Erith was half as salt as pure sea water?—Yes.

9528. And this diagram shows the amount of saltness in the same 10 places at high and low water upon those three days, the 14th and 22nd of September, and the 30th of November?—Yes.

9529. I notice rather a remarkable bulge, as I may call it in homely language, opposite Barking and Crossness at low water on September the 14th?—With the spring tide there is a rise of the line there.

9530. That comes, does it not, opposite Barking and Crossness?—Yes.

9531. There seems to be a considerable increase of chlorine there?—There is a rise in the chlorine line there.

9532. Whether that came from the sewage or not you do not know; you found it there?—I have simply taken the analyses given me. I should like to point out that the reason of plotting this for my purpose was, to show how very greatly the quantity of upland water affects the position of the chlorine lines; any increase in the quantity of upland water drives down the chlorine lines very much indeed.

9533. If you compare the 30th of November with September the 14th, what do you find?—That the increase of upland water has driven down the chlorine lines very much indeed, and I shall venture to use that presently, because I am going to make an assumption about what would happen if the quantity of upland water were very small.

9534. Have you anything further to say upon that diagram?—Just one word. I notice one thing in Professor Way's analyses, that the saltness of the water taken at the surface is a little, but not very much, less than the saltness of the water taken at a considerable depth. One explanation of that would be that the tidal water found its way up underneath the other water, but it seems to me more probably due to the fresh water of the tributaries spreading out upon the surface, and not all at once mixing with the water below.

9535. (*Sir John Coode.*) If there were no tributaries below Teddington Weir, do you think that the difference between surface water and the water below would remain to the same extent?—I think if there were no tributaries the mixing would be perfect, at no very great distance from Teddington, the action of the mixing is so great.

9536. (*Mr. Lumley Smith.*) Now will you take Diagram 5?—Diagrams 5 and 6 are to be taken together.

9537. You will explain upon what principle you prepared those diagrams, and what they represent?—I have sought to find the condition of the river at different sections in some way which should involve the very smallest amount of assumption. The principle upon which I proceed first of all is this, I say that the water above Crossness consists of pure river water which has come down from Teddington, and of the denser water which has come up from Crossness. Any water which increases the density of the river above Crossness must be water which has passed Crossness on its way up, and therefore I can take the

chlorine analyses, and by means of those I can divide the water above Crossness into pure river water and water which has once been at Crossness. The result of applying that calculation for high water and for low water on September the 14th is shown upon these two diagrams.

9538. I do not know that I quite follow you, perhaps the members of the Commission do,—you say that you can separate the water which has never gone below Crossness from what has been below Crossness, is that by knowing the amount of chlorine in the water below Crossness and also the amount of chlorine in the water which has never been below Crossness?—By knowing the amount of chlorine in the water at Crossness and the amount of chlorine in the water at Teddington, and the amount of chlorine in the water at any given section.

9539. You are not now dealing with the mixture of river water, sewage and sea water by distinguishing between the water which has been below and what has come from above?—That is so.

9540. (*Mr. Michael.*) Have you assumed the chlorine in the mixture is entirely due to the sewage?—I have not come to the sewage yet. I say that anything which increases the density of the water above Crossness is something which has come from below Crossness.

9541. (*Mr. Lumley Smith.*) By observation we can find the amount of chlorine in the water at Crossness, and also above it?—Yes.

9542. Before we pass from that will you explain what your shading lines mean?—The whole of the cross-hatched part, including the part marked "sewage" is the quantity of Crossness water found by that calculation at each section.

9543. You got those different places, Teddington, Chiswick, St. Paul's Pier, Deptford, North Woolwich, Barking, and Crossness. I suppose at Teddington the vertical ordinate represents the amount of water there; that is all fresh water?—It is all fresh water, but it represents the section of the river.

9544. (*Sir John Coode.*) I understand the left hand hatched line represents the whole river section?—Yes, the whole river section.

9545. And the dotted line to the right of that, and the hatched portion to the right of that again represent the proportion of that area which is occupied by water which has once been at Crossness?—Yes, by water which has once been to Crossness.

9546. (*Mr. Michael.*) And the outer division is occupied by water which has not reached Crossness?—Yes.

9547. (*Mr. Lumley Smith.*) Starting at Teddington as Sir John Coode has pointed out, that upright ordinate represents the section of the river?—Yes.

9548. And the whole of that is pure water which has never been below Crossness?—Yes.

9549. When we come to Chiswick a vertical ordinate drawn there would represent the section of the river, and it also would represent water which had not been below Crossness?—That is so.

9550. When we come to St. Paul's Pier, having passed Chiswick, we find that the section of the river is partly occupied by water which has been below Crossness, and partly by pure river water?—That is so.

9551. It slightly increases until you come to Crossness, when the whole of it is water, with the same amount of chlorine as you get at Crossness?—Yes.

9552. The cross-hatched part would represent the Crossness water, and to get the relative amount of pure water and Crossness water at any point you have to draw an upright ordinate and compare the length of that in the white with the length of it in the cross-hatched part?—Yes.

9553. Before you pass away from the left hand portion of the diagram are you going to speak of the additional cross hatching for "sewage," or will you wait later to come to that?—I think I would rather deal with the Crossness water first. Taking the right hand diagram, I say that below Crossness the water in any section consists of water which has come up from the sea and the water which has gone down from Crossness.

9554. You know the amount of chlorine at Crossness, and you know the amount of chlorine in sea water?—Yes.

9555. Therefore anywhere below Crossness, by seeing how much chlorine there is in a sample pailful of water, you can tell how much water has come from above Crossness and how much has come from the sea?—Yes, quite so.

9556. Will you explain what you have done?—I have calculated for each of those ordinates; the portion of the section which is occupied by Crossness water and the proportion of the section which is occupied by sea water.

9557. Does that dark line represent the section of the river?—The dark line represents the section of the river, the scale being now reduced 10 times.

9558. And then you find at Crossness that the whole of the river is occupied by Crossness water?—The whole of the river at Crossness is occupied by Crossness water.

9559. At Southend it is diminished very considerably; nearly the whole of it is sea water?—Yes.

9560. So that at any part from Crossness to Southend the relative quantity of water from above Crossness and sea water can be ascertained by simply putting the scale in the ordinate drawn uprightly?—Precisely.

9561. You also show the ratio of the Cray and Darenth water; why is that?—The only tributaries of importance in the water below Crossness are some which come in between Erith and Gravesend, and which for my purpose I assume come in at Gravesend. I have assumed that those consist of pure water, and on that assumption I have tried to find out how much modification of the diagram would be necessary to allow for that quantity of water coming in at Gravesend; and I have drawn the area of the Cray and Darenth water; there are several other tributaries, but I call it "Cray and Darenth"; they are the only important ones, and their position on the diagram shows that they do not very much affect the whole question.

9562. Is the amount of water that comes in there included entirely in that little cone of dotted lines above the cross hatch?—The space occupied in the river by water which had come in from those tributaries is represented by the area between those two dotted lines; it is not very material. Then I should like to point out that I have handed in Tables 6, 7, 8, 9, 10, and 11, which contain the figures relating to this diagram and to the two other tides. I have not plotted the two other tides, but I have calculated them. I have given in these tables the area of the river water, sea water, Crossness water, and Cray and Darenth water at low and high water for three tides.

Adjourned to Tuesday next at half-past 12 o'clock.

# TWENTY-THIRD DAY.

## Tuesday, 20th February 1883.

PRESENT:

SIR P. BENSON MAXWELL, IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.

WILLIAM POLE, ESQ., F.R.S., *Secretary.*

20 Feb. 1883.

(*Mr. Bidder.*) Probably you will recollect that when Mr. Mansergh was in the box and put in his diagrams, he stated that they were prepared from 134 sections which he had made of the river, and we asked him to allow us to have an opportunity of copying them out, and he was very ready to do so. We have not had that opportunity yet, and, as my learned friend is here, I would ask that we should have it now.

(*Mr. Balfour Browne.*) I remember distinctly Mr. Mansergh said that he had arrived at his results from a large number of sections.

(*Mr. Bidder.*) And then I said, Of course you have no objection to let us have them, and he said, certainly not.

(*Mr. Balfour Browne.*) Subject to the opinion of my leaders, I have no objection to your having them.

(*Mr. Bidder.*) But is it subject to anything, because I will give you the reference to the passage in which Mr. Webster agreed to our having them.

(*Mr. Balfour Browne.*) I will promise to discuss the matter with my learned friends this afternoon, or before to-morrow's sitting, and if they were promised by Mr. Webster, my learned friend will keep his word.

(*Mr. Bidder.*) But even if they were not promised, I should make the application.

(*Chairman.*) Would your application be in the nature of an order upon the witness?

(*Mr. Balfour Browne.*) If there is anything in the way of furnishing information by myself or by our witnesses, we shall be happy to do it.

(*Chairman.*) Let us put it aside for the present, I dare say there will be no difficulty about it.

Professor WILLIAM CAWTHORNE UNWIN recalled; further examined by Mr. BALFOUR BROWNE.

*Prof. W. C. Unwin.*

9563. I think upon the last occasion when the Commission adjourned, you had just called attention to tables 6 and 12, and also to diagrams Nos. 5 and 6; those diagrams I think show the divisions of the water. I want to ask you this question, do those diagrams depend upon any theory of yours, or are they simply a putting in a diagrammatic form, Professor Way's analyses?—The diagrams and the six tables relating to the three tides as far as they relate to the division of the water above Crossness into Crossness water and river water, and as far as they relate to the division of the water below Crossness into sea water, and Crossness water, depend upon no theory, they are a simple expression in volumes of Professor Way's analyses. Those are the six tables relating to the three tides, Nos. 6 to 11 inclusive, and Diagrams Nos. 5 and 6.

9564. (*Mr. Bidder.*) Do Diagrams 5 and 6 relate to those tables?—Yes.

9565. And are founded upon them?—Yes, they are simply a graphic representation of two of the tables.

9566. (*Mr. Balfour Browne.*) Of course these diagrams simply represent the condition of things at the moment of analysis?—They represent the condition of the river at high water and at low water.

9567. As indicated by the chlorine?—Yes, as indicated by the chlorine.

9568. I want to go now to the question of the quantity of sewage in the Crossness water; what would you divide the Crossness water into?—The Crossness water consists of river water, sea water, and sewage mixed.

(*Mr. Bidder.*) Does that mean water which has come out of the Crossness sewers?

9569. (*Mr. Balfour Browne to the witness.*) What you are speaking of is water in the river at Crossness?—By "Crossness water" in each of these tables I understand, water which was in the river at the moments when the chlorine analyses were made.

9570. (*Sir John Coode.*) Do you mean taken at the centre, or at the one side or the other side, or both sides or how?—Professor Way can tell you that better than I can. I believe they were taken across the river.

(*Mr. Balfour Browne.*) They were taken across the river, three or four samples at each section of the river, and I believe the mean of the whole was taken.

(*Mr. Bidder.*) What Professor Unwin means I believe by Crossness water, is the water which was represented by a certain analysis which was said to have been taken of the water at Crossness.

(*Witness.*) I might take any section of the river and divide it in this way; above, into water which was as salt as pure water, and water which was as salt as that at the section; below, into water which was as salt as that at the section, and water which was as salt as sea water.

9571. (*Mr. Bidder.*) But your samples were not taken at the same moment?—There were six sets of analyses, three of them taken at high water on one tide, and three of them taken at low water on another tide.

(*Sir John Coode.*) No. 6 is taken at low water on September 14th; No. 7 at high water on September 14th; No. 8 at low water on September 22nd; No. 9 at high water on September 22nd; No. 10 at low water on November 30th, and No. 11 at high water on November 30th.

9572. (*Mr. Balfour Browne.*) What you have done I think is to take one of those tables and turn it into a diagram?—I have taken two of them.

9573. At high water and low water?—Yes, at high water, and low water on September 14th.

9574. And those diagrams are given as Nos. 5 and 6?—Yes.

(*Sir John Coode.*) You will give evidence by and by to show exactly how these samples were taken?

(*Mr. Balfour Browne.*) Certainly we shall.

(*Mr. Bidder.*) In point of fact they are the foundation of all the diagrams and tables which the witnesses have been serving up to us in so many forms.

(*Sir John Coode.*) Therefore it is all important that we should know how they were arrived at.

9575. (*Mr. Balfour Browne to the witness.*) With

regard to the Crossness water, which as you say, consists of sea water, river water and sewage, how do you find out what quantity of sewage is in that water; what process do you go through?—There are three quantities to determine, and we must therefore have three equations; those are based upon these three conditions, first, that the sum of the salt in the river water, of the salt in the sea water, and of the salt in the sewage must be equal to the observed quantity of the salt of the section, that is to say, the total quantity of the salt in the river water, sea water and sewage, must be equal to the observed quantity of the salt of the section. Secondly, the sum of the areas of the river water, sea water, and sewage, must be equal to the known area of the section. And, thirdly, the ratio of the water of the river and sewage water must be equal to the known ratio of the quantity of sewage supplied in a tide, to the quantity of upland water supplied in a tide.

9576. Which is the most important thing in this place to determine, the quantity of sewage, or the proportion of sewage in the water at Crossness, what other point?—The point to determine is the quantity or proportion of sewage in a cubic foot of water; we are interested in the sewage more than in the other constituents of the water.

9577. So far as we are concerned, it does not matter how much is river, how much is sewage, and how much sea water, but how much is sewage in proportion to those—that is the important point?—Yes.

9578. The quantity of sewage in a unit volume of water at Crossness, you give for this purpose a particular name to?—I call it the sewage density.

9579. And have you given values to it in your tables?—It is given in two columns in the six tables to which I am referring.

9580. The heading of the column is "Ratio of sewage section to whole section"—now, whenever the water of Crossness goes down stream, or up stream, does it carry the same proportion of sewage with it?—It carries with it the same proportion of sewage, or of materials which have been sewage.

9581. The question whether they have ceased to be sewage is of course a chemical question?—That is a question which is out of my view.

9582. Can you therefore divide the Crossness water for the whole length of the river into sewage water, and not sewage water?—The tables and the diagram show the distribution of sewage obtained by dividing the Crossness water into sewage, and water which is not sewage.

9583. And that shows the volumes at every part of the river?—Yes.

9584. I see that one-half of these diagrams is on a very exaggerated scale, it is exaggerated five times?—It is exaggerated ten times upon these two diagrams.

9585. And that curve upon that diagram No. 5, shows the distribution of sewage, the whole length from Teddington to Southend?—Yes.

9586. And the same with diagram, No. 6, only taking it to Southend at low water?—Yes.

9587. Are those two diagrams drawn to the same scale?—Yes, they are drawn to the same scale.

9588. There may be something said as to the way in which the sewage enters at Crossness, and have you made calculations upon various hypotheses, the first of which is upon the supposition that it enters uniformly at Crossness?—In dividing the Crossness water into sewage water and water not sewage, I have assumed that the sewage at the Crossness section bears the same ratio to the river water that the sewage supplied in a day bears to the upland water supplied in a day. In order that that assumption may be right, I must assume that the sewage is uniformly delivered into the river during the period of an ebb.

9589. In what time is that?—Between six and seven hours, that is at all events, I assume that it is so delivered that, over about 10·8 miles length of the river, it is distributed uniformly. Now if the only sewage in the river were that delivered in one tide, the assumption would not be a very exact one; but as the length of river corresponding to the tidal range, about 10·8 miles at Crossness, contains the sewage of from 12 to 15 days, or from 24 to 30 tides, then the slightly non-uniform distribution of any one day's sewage very little affects the question. The mixing action which goes on in that length of tide will make the distribution tolerably uniform, and the non-uniform distribution of one day's sewage as I say, very little affects the question.

9590. If, of course, the Crossness water were passing into an absolutely pure river, the result would be different?—In the case of an absolutely pure river, I should consider the supposition not an exact one, but the quantity coming into the river on one tide being only one twentieth or a thirtieth of that in the whole section, the uniform distribution of it does not seem to be very important.

9591. Do you make any correction or allowance for the tributaries running into the Thames; first, taking a pure tributary above Crossness?—If a pure stream enters above Crossness its saltness is the same as of the Teddington water, and by the method I have adopted, it is estimated as Teddington water; therefore it does not involve any error in the tables.

9592. If a polluted tributary enters the river above Crossness, what is the result?—If a polluted tributary enters the river above Crossness, its saltness is very much less than the saltness of Crossness water, which contains a portion of sea water; therefore a polluted tributary which enters above Crossness will be chiefly estimated as Teddington water; and therefore to the extent to which polluted water enters above Crossness, the diagram shows less sewage than there really is in the upper part of the river.

9593. Having shown the Commission what took place when these samples were taken at high water and at low water on the 14th September, I want to ask you this: up to this point you are dealing with what I understand you to say are actual facts if the chemists are accurate; but what would happen in the case of excessive dry weather?—The diagram and tables simply represent the condition of things observed by chemists upon three actual days; on one of those days, the 14th, there was about the mean quantity of water at Teddington; on the other days there was a great surplus of water at Teddington. It seems useful to inquire what would happen if the supply of water at Teddington were reduced to its lowest summer amount, and I have calculated an imaginary tide corresponding to such a period of drought.

9594. Coming in wen the supply of water was excessively low?—Coming in when the supply of upland water was excessively low.

9595. Such a tide as might come in in dry summer weather, is that so?—Quite so.

7596. Will you explain what you mean?—The only pure assumption one has to make, is the assumption about the amount of saltness in the river. The diagram of saltness (No. 4.) shows clearly that as the supply of upland water is diminished, the amount of saltness in the river increases, and goes further up stream. Looking at that, I have made this assumption: I have supposed that the saltness of the river from Crossness towards the sea would be exactly the same as on the 14th September.

9597. (*Mr Bidder.*) At high or low water?—I have only calculated the low water—that from Crossness upwards, the saltness would uniformly diminish to Teddington.

9598. (*Mr. Balfour Browne.*) Have you taken a quantity representing the quantity of upland water?—The volumes I took were, for the upland water 30,000,000 cubic feet in a tide, and for the sewage 10,000,000 cubic feet in a tide — that is 3,450,000 less than I have taken on ordinary days.

8599. The 3,450,000 you are speaking of less, only refer to the sewage?—Yes, the upland water is the known minimum supply at Teddington, and the sewage I have taken at 3,450,000 cubic feet per tide less than the ordinary supply; making the calculation, I find

*Prof. W. C. Unwin.*

20 Feb. 1883.

that there would be at Crossness one cubic foot of sewage in five cubic feet of water. Then, proceeding as with the other tides, I have calculated the quantity of sewage at other sections of the river, and that is given in Table 12.

9600. (*Chairman.*) Do you show that upon the diagram ?—No, the calculations corresponding to those I have been speaking of are given in Table 12.

9601. (*Mr. Balfour Browne.*) Can you tell from those tables the total sewage above any section of the river in days' supply ?—Yes, estimated in days' supply. It appeared to me that the most convenient unit for considering the amount of sewage would be a day's supply of sewage. I have taken a day's supply of sewage at 26,000,000 cubic feet. Now, in Table 14 and in diagram 8, I have shown by ordinates the total sewage above any section in units of days supply. It will be seen that the total number of days' supply in the river was a little over 39 days upon September 14th, and a little over 28 days, from 28 to 31 days, upon the 22nd, and a little over 12 days upon November 30th.

9602. You have put upon this diagram in a solid black line, an "Ideal low-water spring tide;" what does that run up to ?—In a period of drought I estimate that there would be 59 days' sewage in the river.

9603. Upon this diagram one side is the same as the other, only multiplied by five ?—Multiplied by five.

9604. Does this show the mean ? Have you calculated upon the table the mean of high and low water ? —I have not. I think upon the whole it is preferable to deal with the conditions of the tide independently.

9605. I see that you put down both the high and low water upon all the observed days ?—Yes.

9606. And the ideal low water is calculated in the way you have described to the Commission ?—Precisely so.

9607. Which only depends upon the one assumption as to the saltness which you have described ?—Only upon that one assumption as to the saltness.

9608. Have you worked out the percentage of sewage or material derived from sewage in the water, and in which table is that shown ?—In Table 15 and in diagram 7, I have shown the percentage of sewage in the water. The interesting part of that diagram is, I think, the way in which the percentage of sewage is extraordinarily diminished upon the 30th November, when the supply of upland water was very large ; and in connexion with that you will notice the very great rise of the ideal spring tide line in drought, at low water, which is due to the known diminution of the water at Teddington.

9609. The very fact that the line representing the percentage of sewage upon the 30th November is very much depressed, is the correlative fact to the one that the ideal spring tide is very much elevated ?—Precisely so.

9610. Showing that the effect of the upland flood water is very great in driving the sewage out ?—Precisely so.

9611. Have you considered the effect of removing the sewage outfall from Crossness or Barking to Gravesend ?

(*Mr. Bidder.*) But I thought it was understood——

(*Mr. Balfour Browne.*) I am not going into any question of remedy, it is simply a question of volume again.

(*Mr. Bidder.*) I am quite willing ; but I thought it was decided to limit the inquiry to that branch of it which the chemists were inquiring into, namely, the present state of things.

(*Chairman.*) Let us see the object of the proposed question.

(*Mr. Balfour Browne.*) The question is, how much it would reduce the sewage density if, instead of the sewage being poured in at Crossness, it were poured in at Gravesend. I am not proposing another scheme to deal with the sewage, but simply asking what would be the effect upon the density under these altered conditions.

(*Mr. Bidder.*) That is a very simple question, but it opens the floodgates to the whole of the other branch of the inquiry.

(*Witness.*) I should be very glad not to give an answer to the question.

(*The Commissioners consulted together.*)

(*Chairman.*) We think that though we adhere to the line we originally proposed to ourselves, namely, to address ourselves to the remedy as a distinct branch if we should think a remedy is necessary ; still we do not think we ought to draw a hard and fast line for the purpose of excluding a question like this. I understand you to say that you do not put the question for the purpose of inviting the witness to give his opinion as to what remedy he would propose, supposing a nuisance to be created.

(*Mr. Balfour Browne.*) Certainly not ; it is only to show how much the density of the sewage would be diminished, if instead of being poured in at Crossness or Barking, it were poured in at Gravesend.

The Commissioners allowed the question to be put.

9612. (*Mr. Balfour Browne to the witness.*) Would you answer the question. What would be the effect upon the sewage density, if, instead of the sewage being poured in at Crossness, it were poured in some miles lower down ; say, at Gravesend ?—After the most careful consideration of the way in which I have been dealing with known facts, it appears to me that if you introduced the sewage at Gravesend instead of introducing it as now at Crossness and Barking, the amount of sewage throughout the river would be reduced to a little less than one half. You would not do more than that ; and the bearing of that statement upon the inquiry is that there is no point upon the river at which the sewage can be introduced which will keep the sewage entirely out of the upper part of the river.

9613. You wrote a little work upon the movement of water in a tidal river with reference to the position of sewer outfalls, and it is published by Messrs. Spon, I believe ?—Yes.

(*Sir John Coode.*) Is it of any tidal river, or, of the Thames in particular.

(*Witness.*) The work was called "the movement of water in a tidal river," and the calculations were based upon the Thames.

9614. (*Mr. Balfour Browne.*) When did you write this work ?—It was written last December, shortly before I came into any relations with the present inquiry.

9615. There are one or two things which suggest a question. I see on page 8 of the work you say——

(*Mr. Bidder.*) I think this is hardly a convenient way of examining the witness.

(*Chairman to Mr Balfour Browne.*) You might use the pamphlet as your brief, and ask him what is his opinion upon a certain point.

(*Mr. Balfour Browne.*) The only reason is that Professor Unwin has explained his views very clearly, and there would be a risk of misunderstanding unless you had the book before you.

(*Chairman.*) The question the learned counsel would put to you is, are you of opinion that the tidal action alone effects directly any change in the material water in the river.

(*Witness.*) I think the statement there is strictly correct, that the tidal action alone independently of any mixing, effects no change in the material water in the river.

9616. Then what is the nature of the action of the tide ?—The action of the tide alone, apart from what I have classed as mixing action, is merely to produce a comparatively short reciprocating oscillation.

9617. About what length ?—6 to 10 miles upon a spring tide.

9618. And upon a neap tide ?—Upon a neap tide less.

9619. (*Mr. Balfour Browne.*) Does that which you

have stated to the Commission about oscillation take into consideration the mixing action or not?—It expressly excludes the mixing action; that is accounted for afterwards.

9620. Mr. Latham I think quoted from his work when he was in the box. Then on page 10 you say Volume not a very large factor in tidal action."

*Mr. Bidder* objected to the question.

*The Chairman* intimated that the learned counsel had no right to read the pamphlet to the witness to ask him if it was correct, but that he might use the pamphlet as a brief, as suggesting hints for the examination of the witness in chief.

(*Mr. Balfour Browne to the witness.*) Is it your opinion with regard to the mixing action that volume i s not a very large factor in the tidal action?—There is clearly some mis-apprehension there.

9621. Will you just explain what you mean?—What I have said expressly, is that the volume of water which is exchanged with river water in one tide, is not large compared with the whole tidal volume; I still think that that is quite correct.

9622. I will ask you another question without reference to the book; is the general effect of your calculations to show that the exchange of sea water and river water takes place more slowly than is commonly supposed?—That refers to my opinion expressed earlier, that many people think there is a more or less complete emptying of the river and filling of the river upon every tide, and it is strictly accurate to say that that is not true.

9623. It refers to what you have just explained to the Commission, I think?—Quite so.

9624. (*Mr. Bidder.*) I never met a person who thought the river was completely emptied and completely filled at every tide?—I think I could find some statements implying that view.

9625. (*Mr. Balfour Browne.*) I think I understood you on the last occasion, when dealing with the oscillation of water in the river, to say that you thought the float observations were valuable for ascertaining the amount of tidal oscillation?—My point is that the floats show a range of tide somewhat greater than the actual mean oscillation of the tide, but that the floats do show the actual motion of a certain portion of the water.

9626. For that purpose you have treated them as you have done?—Yes.

Cross-examined by Mr. Bidder.

9627. Now I gather that of personal observation of the Thames in connexion with this question, you have none?—I have made a good many observations upon the Thames.

9628. Of course we have all been upon the Thames; there is nobody here who has not been on a penny boat at some time or other; but of personal obsetvations you have not made any, have you?—I have made many observations of a kind which throw light upon this inquiry.

9629. All your diagrams, and all your tables, and all your evidence before the Commission, are based upon three classes of facts I think; just follow me please and see that I am right; first, certain measurements of sectional area of the river which you obtained from the engineers; is that right?—Quite so.

9630. Secondly, certain gaugings of the upland water, and calculations of the amount of sewage, which you got from Mr. Baldwin Latham?—Yes.

9631. Thirdly, upon certain analyses of Professor Way, as to what he found to be the number of parts of chlorine in 100,000 parts in certain samples of water which are said to have been taken from the river at certain times?—Yes.

9632. That is the whole substratum of fact upon which the edifice has been erected; do not let me leave anything out, I think I have got it all; and the distances of course you got from the plan or the ordnance map; but there is nothing else, is there?—I think that embraces the most material facts I have to deal with.

9633. You had to make a certain number of assumptions in arriving at these conclusions, had you not?—So far as I have made any assumptions, they have been quite explicitly stated.

9634. Do not suppose for a moment that I am complaining in any way of the manner in which you have given your evidence. I am not suggesting that the assumptions were not put forward with perfect frankness and fairness, but I should like to ask you this question. In the first place, where is Table No. 1?—Table No. 1 is only a table of areas, and I did not think it worth printing.

9635. It sometimes does so happen, but I think for the moment it is the most important table of the lot. Now, first I will take Tables Nos. 2 and 3, and I think you will want Table No. 1 to answer my question. Taking those tables, I find that you have given us the volumes between consecutive sections in cubic feet. In the first instance Table No. 2 relates to two tides, September the 14th and 22nd, both at high and low water?—Quite so.

9636. Now I have before me a similar table which was put in by Mr. Mansergh, the engineer, namely, Table M 3*a*. I do not know whether you are aware of it, but the results in Mr. Mansergh's table, appear to differ considerably from those in yours. I will ask the question generally, first, you are aware that Mr. Mansergh has dealt with exactly the same facts, and has produced certain results from those facts?—Yes, I am aware of that.

9637. Are you aware that Mr. Baldwin Latham has also given evidence making deductions from those same facts?—I am.

9638. Are you aware that Mr. Peregrine Birch has also given evidence making deductions from those same facts?—I am.

9639. Are you aware that you differ in some respects among yourselves very considerably?—I am not aware of that.

9640. Upon this subject of area and volume, as far as I can make it out, there are differences between you and Mr. Mansergh. Upon what principle have you arrived at the contents of each division; how did you get at it; what you were given as I understand, were sectional areas?—I have taken the mean of the two sections and multiplied by the distance between.

9641. Do you mean to say that if one section were 100,000 feet and another were 120,000 feet, you have taken 110,000 feet and multiplied it by the distance?—Quite so.

9642. Are you not aware that that is utterly wrong as a matter of arithmetic; do not you know that the cubical content and the volume of the river cannot be arrived at in that way; that in many cases it would give a most erroneous result?—I believe it is the most accurate method which you can adopt with the number of sections and with the data which are here at disposal.

9643. But pardon me, supposing you get a river gradually widening, either a conical section or prsimatic section or whatever you like, surely you know that the area of that section is not represented by the mean of the section multiplied by the distance?—In all practical problems, it is no use attempting an accuracy beyond the accuracy of your data, and anyone who will look at the longtitudinal section of the river varying from yard to yard in the section, will know that the conclusions at which I have arrived are as accurate as any conclusions from those data are likely or possible to be.

9644. But you know there is a recognized formula for dealing with these matters, any engineer's clerk would have known how to go to work about it?—There are many rules, prismoidal rules and so on, which are more accurate than those which I have adopted, in the case of railway embankments for instance; but I believe they would be less accurate

*Prof. W. C. Unwin.*

20 Feb. 1883.

in the case of the river, which I have had to deal with.

9645. You mean they would be more accurate with a regular widening, but you admit that the plan you have adopted, would give an erroneous result in the case of a river, supposing it were a case of regular increase?—The prismoidal rule is as much a theoretical rule as the one I have adopted.

9646. But you know that the prismoidal rule is not a theoretical rule, in the sense of being uncertain you know; it is as certain as that two and two make four.

(*Chairman.*) But is that so, because it is rather putting it to the witness as a statement?

9647. (*Mr. Bidder.*) I should strictly perhaps have asked the witness, whether it was true that two and two make four. (*To the witness.*) Do not you know that what you call the prismoidal rule is matter of absolute demonstration, assuming the river is regular in its increase?—If you make that assumption.

9648. Will you first answer the question, do not you know that what you call the prismoidal rule is a matter of absolute demonstration, assuming that the river is regular in its increase?—I must ask you to define what you mean by "regular increase." There is no railway embankment and no river in which the increase is exactly regular.

9649. (*Chairman.*) Assuming Mr. Bidder's fact that the river does increase regularly, then is not the prismoidal rule one capable of mathematical demonstration?—There are many kinds of regular increase; for one kind of regular increase, the prismoidal rule is exact, and for another kind of regular increase, it is not exact.

9650. (*Mr. Bidder.*) If the river increases regularly in this sense, that for instance from one area to another, you might join straight lines, so that it is part of the frustrum of a pyramid, then would not the prismoidal rule apply?—That is not the basis of the prismoidal rule, a prismoid has two edges parallel.

9651. I assume that I know what you mean by the prismoidal rule, it means this, does it not, that taking the section of the river at one point and at another point, and assuming the variation of the upper small section, to the lower and larger section, as represented by joining them by straight lines, then the prismoidal rule is absolutely accurate?—No that is not quite so.

*Mr. Bidder sketched a diagram, and exhibited it to the Witness.*

9652. Does the prismoidal rule exactly apply there?—You have drawn your lines to meet in a point, they may meet in a line. The solid may be a wedge.

9653. (*Mr. Abernethy.*) Is there any section of the River Thames where you could connect the sections by a straight line in that way?—Certainly not. It is my deliberate opinion that the plan I have adopted, is the best plan that could be adopted in the particular case which I have been calculating.

9654. (*Mr. Bidder.*) But if the increase were regular in the sense in which I have drawn it here, then is the prismoidal rule the right one?—Not if the regular increase is the increase of a wedge.

9655. But I said if the increase is a regular increase in the sense in which I have drawn it here?—But you have added the assumption that the river goes to a point.

9656. No, not at all. Now again, to put it another way, there is no known form of increase in which your plan would be right, is there?—Yes, certainly there is.

9657. What is it?—There is certainly a mode of increase in which it would be right, though I am not prepared to work it out at the moment.

9658. In fact, I think I may put it in another way—let me suggest this—if the area of the river increased without any increase in width, but simply increased by increase in depth, then your formula would be nearly right?—And equally if it increased in width without increase in depth.

9659. If it increased only in any one dimension, but that is not what it does?—It is very nearly so; it is very nearly constant in depth, and increases in width.

9660. Are you very positive that the Thames does not increase in depth?—Between any two sections the increase in depth is not very great, but the increase in width is sensible.

9661. Do you know to what extent your adoption of that rule as compared with the rule which the engineers have adopted has brought out a totally different result?—I protest against the term "which the engineers have adopted," because the whole of the canals in India, I believe, have been taken out upon the plan I have followed.

9662. Do you know that the rule you have followed has brought out a totally different result from that brought out by Mr. Mansergh, and to what extent you differ?

9662*a*. (*Chairman.*) Do you know what it amounts to?—I do not know upon what rule he worked.

9663. Do you know that there is something like 25 per cent. between Mr. Mansergh's figures and yours?

9664. (*Mr. Bidder.*) Take your Table No. 2 and I will take one illustration—the 14th of September. Mr. Mansergh has divided the river into two sections, above and below Crossness; now take high water of the 14th of September, and below Crossness, I think you will find that you represent 448,880,000, which you will get by adding the three last figures together?—Yes, about that.

9665. Now, if you will look at Mr. Mansergh's paper for the very same day and time, Table M 3*a*, from Crossness to Southend, and if you add the figures in his No. 3 column for high water upon the same day you will find that they come to 352,893,000?—I will assume that you are right, and I will give you an answer why it is.

9666. I had rather you did not assume that I was right, because afterwards it might be said "Still you were wrong after all"?—These are rather awkward figures to add up.

9667. I will only point out to you that Mr. Mansergh's content is represented by 352,000,000 and yours is represented by 448,880,000?—I will only remark upon that, that out of my whole volume of 448,880,000 cubic feet, 367,900,000 cubic feet are in one single section; that is the section between Gravesend and Southend; that happens to be an immensely long section, and immensely wide; and, as we have only two cross sections for that immense volume, which is more than three fourths of the whole volume, there is likely in that section to be a great difference between us.

9668. But pardon me; this just shows the result of taking this unusual formula of yours, you and Mr. Mansergh were working upon precisely the same materials?—Yes.

9669. And having exactly the same materials to go on, you have brought out results which vary to the extent of 27 per cent.?—The fault is want of data, not defective calculation; the want is of more sections between those two points.

9670. Then the data are so defective, that the greatest and ablest men of their age may vary in the results they produce by 27 per cent.?—In this particular instance, the data between Gravesend and Southend are defective, if you want to follow them out to get exactly the content of the river.

9671. But just follow that out, the defective data leading to the difference as to the content of the river lead also to differences in the quantity and proportion of the sewage in the river?—In one section they do.

9672. And that is the biggest section containing three-fourths of all the water; the section below Crossness?—I believe we have all been perfectly well aware, that in that section, we had very few sections by which to determine so very large a volume.

9673. And that section being the section which according to your assumption contains three-fourths of the water, and three-fourths of the sewage which you are giving evidence about below Crossness?—I thought that the interesting part of my evidence related to another part of the river.

9674. I am told that if I go to the upper parts I

shall find, though not quite so great an extent of discrepancy, still a very large extent of discrepancy; I am afraid up there, your sections are not quite the same as Mr. Mansergh's?—I really have not looked at Mr. Mansergh's results at present; I have been too much engaged upon other matters.

9765. Still I put it to you, if you and Mr. Mansergh, both being eminent men, looking at these data, come to results with a difference of 27 per cent., how can the Commission rely upon the results you arrive at, upon other points of the case?

(*Chairman.*) That might be put to the Commission rather than to the witness.

(*Mr. Balfour Browne.*) But Mr. Mansergh had at his disposal a very large number of sections which Professor Unwin had not at his disposal at all.

9676. (*Mr. Bidder.*) Then that is your first assumption that that formula, taking the mean, will give you correct results?—I protest against your saying that I am of opinion it will give me correct results, I say that taking the only data at my disposal, it was the best method I could follow; if I had had a greater number of sections at my disposal, I might have followed another rule.

9677. Your next assumption was that the ratio of the sewage to river water upon any particular day is equal to the known ratio of the sewage coming out of the sewers to the upland water as gauged upon that day?—That is putting it inaccurately. Surely, I have not said anything exactly equivalent to that; I have certainly not said that; what I have said, is that at a particular section, the Crossness section, the quantity of upland water, and the quantity of sewage which crossed the section in one tide are known, and their ratio is known.

9678. You followed, as I understand, the same process as Mr. Mansergh did—you have taken Professor Way's analysis of chlorine, and you have deduced from that inferentially the proportion of sea water and fresh water, have you not—that was your first step?—I have nowhere done that.

9679. Then if you have not got it from Professor Way, from what source have you got the proportion of sea water and fresh water in any section of the river?—I have nowhere calculated the proportion of sea water and fresh water in the river.

9680. Then it must be my fault. Will you tell me upon what theory you based your inferences as to the proportion of sea water and fresh water in the river. I will take for instance, Diagram No. 7, at low water spring tide on September the 14th at Crossness; I find for instance at Crossness, that you got 12 per cent. of sewage upon the whole section, and you also give in Table 6 in certain cases though not in others, the area of sea water, and the area of Crossness water, and so on?—Yes. I want to point out that my method is in no way identical with Mr. Mansergh's.

9681. Then I was mistaken in supposing that you had adopted a similar method to that taken by the others. Now, take Table No. 6, the first column gives us what Professor Way gave you, the chlorine in 100,000 parts of water at certain places at low water upon the 14th of September—that is information received from Professor Way's analyses?—Yes.

9682. The next column is the sectional area as given by the engineers?—Yes.

9683. Now after that, having got those particulars, will you just explain how you went forward and got the rest?—Shall I take one section.

9684. Take Crossness, the one I pitched upon with 470 parts of chlorine?—I say that at the Crossness section there were at low water upon that tide 30,337 square feet of Crossness water.

9685. Inasmuch as you call Crossness water that which was at Crossness at that time, that is simply saying that X is equal to X, and I am about where I was you know. Perhaps you will tell me, how from that interesting and recondite fact, you produce the further fact, that the area of sewage was 3,761, and the ratio of the sewage was 12 per cent.?—I say that at the Crossness section there were 3,761 feet of sewage in the section.

9686. Where does that come from?—That you have crossing the section at Crossness in one tide, 69,150,000 cubic feet of pure upland water, and 13,450,000 cubic feet of sewage.

9687. Now with regard to the 13,000,000 cubic feet of sewage, I can easily understand how you get that—that is a little more than half a day's sewage?—It is very little more than half a day's sewage, because I take the tide at 12 hours 25 minutes.

9688. Now upland water at Crossness 69,000,000 cubic feet, where did that come from?—That was the gauging at Crossness on that day.

9689. You could not have had a direct gauging of the quantity of upland water at Crossness; that is impossible?—If you wish I will explain what the whole method of these calculations is—it must be understood that the external conditions remain constant, and that if there were 69,000,000 crossing upon the 14th of September, there had been that quantity crossing for a whole month.

9690. But how do you know there had been 69,000,000 cubic feet of water crossing on that day, to begin with?—I mean that 69,000,000 cubic feet crossed the Teddington section upon that day, and came in from tributaries.

9691. Mr. Baldwin Latham gives me in his figures at Teddington Weir, 83,000 cubic feet a minute, and I suppose that is equivalent to your figures?—It is equivalent to 69,000,000 cubic feet per tide; that corresponds with Mr. Baldwin Latham's gauging upon that day at Teddington.

9692. Now I will not interrupt you, but I will ask you to complete your story before I ask you any more questions—69,000,000 cubic feet is Mr. Baldwin Latham's gauging at Teddington upon that day, and 13,000,000 cubic feet is the known sewage discharge; now how do you get to the other figures that the area of sewage is 3,761 square feet, and that your percentage is 12?—The 69,000,000 cubic feet put into the tideway at Teddington, push an equal quantity of water which had come from Teddington across the Crossness section.

9693. But I have not got to the 12 per cent. yet?—Then the ratio of the sewage which entered at Crossness in the period of a tide, to the quantity of river water which crossed the section in that period of the tide, comes out if you calculate it, to the value I have given there as K equals 0·1945.

9694. A little less that a fifth?—Yes, now we can make this calculation; the whole saltness of the river water, sea water and sewage in the Crossness section, is equal to the observed saltness of the section. The areas of the three quantities must be equal to the total area of the section, and the ratio of the upland water to the sewage is 0·1945.

9695. Saying that the whole saltness is equal to the observed saltness of the section, is only saying in other words, that Professor Way's analysis represents truly the saltness of the river?—Only that the saltness of the three individual sections must add up to Professor Way's 470 parts.

9696. Your first equation which I believe is perfectly certain, is that the saltness contributed by the constituents must represent the aggregate saltness, you deduce from the 470 grains, which Professor Way has observed implicitly, (You do not do it explicitly) how much sea water, and how much river water there was in the river; that is to say, how much sewage and and how much sea water?—Yes.

9697. Then you deduce from what you call your K, the percentage of the fresh water which is sewage?—Yes.

9698. That is exactly Mr. Mansergh's process?—Yes, as regards the Crossness section.

9699. The first assumption which strikes me as important is, that the ratio between the quantity of sewage upon a particular day pouring out of the sewers, and the quantity of upland water at Teddington represents the ratio in which the two are combined

*Prof. W. C. Unwin.*

20 Feb. 1883.

in the freshwater at Crossness; that is your first assumption, is it not?—That is one of the assumptions.

9700. The first observation I have to make upon that is, why do you leave out the other upland waters?—This is a matter of detail; but I have not left out the other upland waters.

9701. But you said Teddington?—But I have left out no waters.

9702. Then that is a slip of the tongue, and I substitute for "upland waters" "all the waters coming into the river"?—There is a diagram showing how I have taken all the water.

9703. Then it is a little misunderstanding between you and me, and we will understand all the water to be coming in at Teddington; and I suppose you made the same assumption at Gravesend, or Southend, or anywhere; wherever you want to do the same thing at the lower part of the river, you make the same assumption?—It is the same thing, but I have not required to adopt the same plan there.

9704. (*Chairman.*) I think I undertand you to say that below Crossness you take in the tributaries?—Yes. Below Crossness the tributaries are expressly dealt with. Above Crossness the method used estimates them as equivalent to an equal amount of Teddington water.

9705. (*Mr. Bidder.*) I mean the same thing *mutatis mutandis*. Now does not it occur to you that the fresh water which dilutes the tide water at Crossness or Gravesend, is water which has come from Teddington many days before, to begin with?—Certainly.

9706. Although it is quite true that a certain amount of fresh water poured in at the head of the tidal section of a river must displace an equal volume past every section; that is to say, assuming that the same amount of water is put in every day at Teddington, it is true that the same amount of water must be pushed past every section of the river in 24 hours if the river is in its normal régime; but in the first place it does not follow that the water which is pushed past is that amount of fresh water, it may be mixed water?—It does follow that the same amount of fresh water must be pushed passed every section.

9707. Why is that? I am dealing with 100,000,000 cubic feet poured in every day at Teddington. 100,000,000 cubic feet must pass every section every day, but that need not be fresh water?—It is the simple mathematical law of continuity that if you take two sections of a river, the external conditions of which remain constant, the inflow at one end is equal to the outflow at the other, and further, the inflow of each material at the one end is equal to the outflow of each material at the other; otherwise the condition of the river changes.

9708. Perhaps it does; who knows it does not. Take a long passage full of people, by pushing a man in at one end, you may push out a woman at the other end?—Perfectly so. I will assume that on September 14th there is a very small quantity, 50 cubic feet, less pure water across the Crossness section than came in at Teddington, let us see what that leads to.

9809. But now you are leading me away?—I am pushing out the woman. On September 14th, suppose 50 cubic feet less water went past Crossness than came in at Teddington. Now, there is no reason why on one day rather than on another there should go past Crossness less than comes in at Teddington. If on one day 50 cubic feet less go past, then on all days less go past, and consequently, in a very short time, all the water above Crossness will be pure water.

9810. But we know that the amount of pure water which comes in at Teddington is constantly varying, and sometimes varying very violently?—Yes, that is so.

9811. Now just let me show you where your proposition would lead you, because if upon a particular day the proportion between the sewage running out of the outfalls and the upland water coming over Teddington Weir necessarily represents the proportion all the way down the river of those two constituents, sewage and fresh water, it comes to this, that if by any arrangement we were to stop the sewage, we should absolutely instantaneously purify the whole river upon that day, that must be so?—May I ask you to put that question again.

9712. If your proposition is true, that taking the amount of sewage running in upon a particular day, and the amount of upland water coming in over Teddington Weir, the ratio between those two necessarily represents the proportion in which they exist all the way down the river, then it follows that if artificially or naturally you produce a variation, by either decreasing the amount of sewage you throw into the water, or by increasing the amount of the upland water, you instantly alter it all the way down the river. I see one of the honourable Commissioners thinks I am putting a thing which is absurd, but I will show that I am putting a thing which is not only not absurd, but which actually occurs in practice. Take for instance the 29th and 30th of October according to Mr. Baldwin Latham. Of course we cannot do such a thing as to shut up the sewers for a day, but nature does a thing which is equally violent. Upon the 29th of October, Mr. Latham shows that there were 800,000 cubic feet per minute of water going over Teddington Weir, and the next day that was increased to over a million cubic feet. Now, do you mean to tell us that by that flood coming over Teddington Weir, the whole of the water of the river was changed instantaneously?—I say that there was a change at every section due to the increased displacement, and that the salt line was charged all the way down.

9713. So that the introduction of that extra 200,000 cubic feet of water at Teddington coming down in the sudden rush of a flood, instantly purified to that extent the river 50 miles away?—It instantly purified to the extent of the travel due to the upland water, the whole of that water down to Southend—that is to say, not instantly, but in the period of one tide. The effect of a larger quantity of upland water coming in at the top, is that the whole of the water is displaced down the river by so much from the top of the river to Southend.

9714. But in order to make that true, it must have displaced a great deal more upland water than actually came over Teddington Weir?—Immensely more, but I do not quite understand the point. I think I can meet that by saying that the correctness of these tables assumes that the external conditions of the river had remained constant for some period before the period of observation. As a matter of fact, the external conditions change; the quantity of upland water and the range of the tide changes, and to take into account those changes, it is necessary not to have one table of one tide, but to have several tables of several tides.

9715. Your tables assume a constant flow over Teddington Weir for a long time?—To be strictly accurate, this table assumes that the external conditions both as to Teddington water and as to range of tide, were constant.

9716. Of course you know that when you do increase at Teddington the quantity of water flowing over Teddington Weir, you do not immediately produce a corresponding increase in the section down below—you steepen the gradient of the water?—But, do you steepen the gradient of the water?

9717. Yes; do not you understand what I mean?—No, certainly not.

9718. If in a long river you suddenly introduce by flood or otherwise, a quantity of water coming over at the head of it, you do not produce a corresponding increase in the flow all the way down the river, but the first effect is to pile up the water at the head, the result of which is slightly gradually to increase the flow in each of the succeeding sections?—That is in a non-tidal river; the only mode of transmission down stream of any effect, is the material travelling down of

the water; but in a tidal river you a have a tidal wave which alters things completely. As far as I know there is no steepening of the gradient in a tidal river.

9719. But though you introduce a tidal wave as a complication, yet it is only a complication. If you increase the reception of water, the increase of discharge into the section below must be brought about by increase of head?—If you have a section where the gradient is at no two moments alike, I think it is wrong to say that the introduction of water at Teddington increases the gradient.

9720. Take London Bridge, when the tide is running out, the water is running downwards, and when the tide is coming in, the water is running inwards, and the discharge at London Bridge is the balance of the two; you cannot increase the discharge at London Bridge on the ebb unless you increase the difference of head upon the two sides of London Bridge?—I think I may admit that.

9721. And you cannot increase the difference of head upon the two sides of London Bridge until the accession of upland water has had time to do it?—You will always do it in one tide. I mean to say that the alteration of the low water gradient does not correspond to the increase of the Teddington water.

9722. Now let me pass on to another assumption, namely, the assumption that that which is once sewage is always sewage?—That is assumed for my purpose only.

9723. No account in your diagram is taken of sewage which is destroyed by decomposition?—I, a little object——

9724. Would you mind answering first, yes or no. No allowance is made or account taken in your diagram of sewage which is destroyed by decomposition?—I do not know of any destruction of sewage.

9725. You do not admit its existence, and you ignore it, if it does?—There may be a decomposition.

9726. I do not ask you to speculate as to that. I ask you what you have done—you do not admit its existence and you do not recognise its existence in your tables?—I assume that the sewage coming out at Crossness and Barking remains as a material in the river.

9727. (*Professor Williamson.*) In what sense do you use the word "sewage"—is it to describe a quantity of liquid containing things in whatever state, or containing things in a particular state?—I have said nothing about the condition of the sewage. I have only assumed that that which enters at Barking and Crossness remains in the river, with the two slight exceptions which I have named.

9728. (*Mr. Bidder.*) You take the 26,000,000 coming out at Crossness and Barking, from the tables, as being and remaining sewage to the end of your chapter?—Yes.

9729. You do not take any account of its having been purified by water and so on?—No.

9730. Now you spoke of some people believing in the river emptying and filling with the tide, but in point of fact, we have established by Mr. Mansergh, this: that the river is half filled and emptied every tide; that you admit, do you not, that the tidal section of the river, taking it from, say Southend upwards, is half filled and emptied every tide?—That the volume of tidal water which enters at any one tide is about equal to the low water volume.

9731. That is putting in a very long way, what I put very shortly. Now I ask you this, the next assumption you make is that the fresh or incoming water which is brought in by the high tide from the sea is the old sewage that went out to sea?—I should very much like that assumption to be pointed out in anything that I have said.

9732. In your section, for instance, above Crossness (I will go back to the same illustration) you give as upon the 14th of September upon Table 6, which I was at before, a certain ratio of upland water which you call Crossness water, with a certain ratio of sewage in it?—Yes.

9733. Now you know as a matter of fact, that water, salt, fresh, or sewage, or whatever you please to call it, did come from seaward of Southend, because the content of that section for the first 10 miles above Southend is just half the total content of the river, and therefore it all comes from the sea; do you follow me?—Yes.

9734. I do not know whether it exactly coincides with your first two sections, but for the first 10 miles above Southend it has all come from the sea at high water?—Yes.

9735. You find a certain proportion of salt in that?—Yes.

9736. And you infer from that, that there is a certain proportion of sewage in it?—Yes.

9737. Does not that involve your assumption which I put to you, that water which has come in from the sea, is the old fresh water and the old sewage which has gone out to sea before?—Yes, I think it does. I think I may defend that assumption.

9738. You find from the facts that Professor Way has given, if the samples are properly taken, that there is a certain proportion of chlorine above Southend which you know comes from the sea, and you assume that that fresh water which comes from the sea has exactly the same proportion of London sewage in it, as the water at Crossness opposite the outfall. Now have you investigated the condition of the river and the estuaries, seaward of Southend, so as to form any judgment as to, to what extent that assumption is partially or wholly, or to what extent right?—I have looked at that question, I find that Southend is not the end of the river, that there is still an estuary extending beyond and that into that estuary there comes at all events, one principal river which is also bringing fresh water; but I find that the drainage area of the Medway is only one-tenth that of the Thames; and it is fair to suppose that of the fresh water which there may be at any moment in that estuary, not more than one-tenth has come out of the Medway, and that, that one-tenth, whether it is as impure or not as the Thames water, does not very much affect the question.

9739. Therefore you assume, subject to a qualification of the nature you have indicated, that that must be fresh water that went out of the Thames and must contain the same proportion of sewage?—That is quite right.

9740. And therefore to carry your assumption further, that the proportion between our sewage and the upland water over Teddington Weir actually determines for the day, the proportion of sewage and fresh water there is in the sea itself?—If you mean by the "sea itself," the estuary of the Thames, I say yes, we have taken a perfectly arbitrary termination to the river.

9741. Take Margate?

(*Mr. Balfour Browne.*) Do your tables go to Margate?

(*Mr. Bidder.*) Yes they do.

(*Witness.*) I will make to Mr. Bidder this concession at once; for 10 miles up from Southend, you have water which has come in from—you do not quite know where. I have looked at the question and formed a judgment about it, I may be wrong, but any objection taken upon that ground applies only to the last 10 miles of the river's course; to the 10 miles above Southend. The water which is higher up than 10 miles from Southend, never goes out even of my part of the river at all.

9742. Where did the salt water come from up at Chiswick even, if it did not come from the sea?—It comes from St. Paul's Pier; at St. Paul's Pier, it came from Deptford, and at Deptford it came from further away.

9743. But is there a manufactory of salt at St. Paul's Pier; does not it mean that whenever you find an indication of salt by chlorine, that indicates that the salt water in the mixture must have come from the sea?—No doubt.

9744. Therefore this indicates that the water must

*Prof. W. C. Unwin.*

20 Feb. 1883.

have come from the sea?—I know no other source of water in the river beyond the Thames and Medway, except the sea.

9745. Your table stops at Southend, but Professor Way's analyses do not stop at Southend; he takes the trouble to show you that even down at Margate there was, according to your inference, something like 12 per cent. of fresh water; that is to say, if your analyses are right, upon exactly the same basis, then you ought to assume that there was 12 per cent. of fresh water, and therefore upon the same assumption a certain percentage of sewage?—I should accept the assumption that there was 12 per cent. of fresh water at Margate, and that it contained therefore a certain percentage of sewage.

(*Sir John Coode.*) It would be useful to know at what depth in the water these samples were taken at Southend and at Margate.

(*Witness.*) My point of view is that an enormous volume of fresh water goes out daily from the Thames, it may strike out into the sea, but it need not be dissipated all at once; a current of fresh water may have gone past Margate.

(*Mr. Balfour Browne.*) I am instructed that this sample was taken a foot below the surface, from the end of the jetty at Margate.

(*Sir John Coode.*) I rather suspect that what you have suggested lies at the bottom of it.

(*Mr Bidder.*) I should have preferred to pass from asking these questions now, because there must come a time at which we must ask that question as to the whole of them. Without suggesting for a moment that any of the samples were unfairly taken, yet the question must be asked as to whether they fairly represent the average of the river at these points.

9746. (*To the witness.*) Now will you give me Table No. 1, which represents the areas?—It has not been put in evidence, and I do not know whether it is fair, therefore, to ask for it, but I have no objection to hand it to you (*handing the same to the learned counsel*).

9747. Is this the same as Mr. Latham's?—I believe it is. I got it from the same source.

9748. There is Table No. 13, that we have not had?—It is really the same thing as is given in Table 14, for separate sections, but it is not printed and I have not put it in evidence.

9749. (*Chairman.*) Does such a table exist as Table 13?—I made a table which I call Table 13, but I have not used it in evidence.

9750. (*Mr. Bidder.*) Why did you not use it, did it turn out wrong?—No, Table 14 is based upon it. Table 14 gives you all that there was in Table 13, but in a better form.

9751. Now I have to ask you one or two questions upon these tables in matter of detail. Now, in dealing with these tables in regard to upland water, I am told that you rather ignored the River Lea, or brought it in at a different part of the river from where it does come in; you have treated it as coming in at Barking, is that so?—I have treated all tributaries as coming in at the next section below the one at which they come in.

9752. In Table No. 4 you have Teddington, Chiswick, St. Paul's Pier, Deptford, North Woolwich, and Barking. You bring in the River Lea at Barking, do you not?—I do not know the river personally to any extent, but I have treated it as coming in about Barking.

9753. May I tell you that it would come in at another part of the river between Deptford and North Woolwich?—Mr. Latham measured a large number of streamlets which I had very great difficulty in allotting.

Re-examined by Mr. Balfour Browne.

9754. You were asked whether you had made any observations upon the Thames. I believe you were at one time, in fact for a long time, occupied in making observations of the currents of the Thames, were you not?—I have made a large number of velocity observations and stream observations on the Thames.

9755. Where were they made?—They were made at Putney and in the upper part of the river.

9756. But when you turned your attention to the question of the disposal of the sewage by means of the river, this was not your first acquaintance with the Thames at all?—No, it was not.

9757. And your inspection has not been confined to the penny boat as my learned friend suggested. Now with regard to this method of calculation taken from the section areas, will you tell me exactly what you did. My learned friend says you did not adopt the right method. Will you just tell the Commission what you did?—In this particular case I have believed it most accurate to take the mean of the two sections at the end, and to multiply them by the distance.

9758. And I understand you to say you consider that under the circumstances that is the most accurate method you could adopt?—Decidedly.

9759. (*Mr. Bidder.*) May I ask you one question; were not you rather pressed for time?—I was.

9760. (*Mr. Balfour Browne.*) Is it not the fact that this method has been adopted in large engineering works in India?—It is a common enough method of calculation.

9761. What would be the effect of any error upon that method of calculation; would it tend to increase, or to diminish the area?—I cannot in the least answer that question. The sections of the river vary so irregularly, that it is impossible to predict upon which side the error would be.

9762. With regard to the discrepancy between your volume at Southend, as compared with Mr. Mansergh's, how many sections had you to calculate that from?—For the section between Gravesend and Southend, I only had two cross sections.

9763. Do you know as a fact that Mr. Mansergh had as many as nine sections?

(*Chairman.*) Even if he did know it, it would not matter; you can prove the fact for yourself.

9764. (*Mr Balfour Browne.*) We will prove the fact by putting in the sections. (*To the witness.*) Now with regard to this question, the section at Southend is the least important of all for this inquiry, is it not?—I suppose it is so.

9765. Do not suppose; is it, or is it not so?—It appears to me that the sections up the river are the more important.

9766. I understand your evidence to be that the amount of water coming in at Teddington, displaces the same amount of water in the course of one tide the way whole down the river?—The same amount of water.

9767. Is it the fact that that water must necessarily be the same amount of fresh water, or that otherwise the whole condition of the river would gradually be changed?—Yes, certainly.

9768. That is the theory you have gone upon in one of your tables?—Yes, quite so.

9769. Now with regard to the assumption that once sewage always sewage; what you have been dealing with, is not the chemical question of what becomes of the sewage, but what becomes of certain bodies?—Of what becomes of certain materials.

9770. One of the materials comes out of the sewers at Crossness and Barking, and you call that sewage?—Yes, I call that sewage.

9771. Now with reference to the fresh water coming back, I scarcely followed my learned friend, but is there the least probability that the fresh water which comes back into the Thames, is more probably Medway water than Thames water which has gone out.

(*Mr. Bidder.*) I made no suggestion of the kind.

8772. (*Mr. Balfour Browne.*) Is there any probability of that being Medway, and not Thames water?—I

suppose it is certain that a minute proportion of the Medway water does come up the Thames.

9773. But according to your evidence, the Medway is only a tenth of the size of the Thames ?—Only a tenth.

9774. And the proportion of pollution in the one, could not vary the pollution found in the other ?—It could not make any appreciable difference.

9775. So that supposing a certain proportion of the Medway water to come up the Thames, could it make any appreciable difference in the character of the water ?—No appreciable difference.

9776. (*Chairman.*) In making your ideal tide, you take a very small quantity of water as coming over Teddington Weir; did you know as a matter of fact, that so small a quantity as that ever did come over Teddington Weir ?—Yes, it agrees with what has been given by Mr. Baldwin Latham as the minimum flow of the Thames.

*Prof. W. C. Unwin.*

20 Feb. 1883.

9777. (*Mr. Bidder.*) Upon which day ?—Not any day of ganging, but he stated that in his evidence as the minimum flow. I have compared it with other matters of which I have knowledge and with gaugings which I have taken myself, and I take that as a fact which cannot be much wrong.

9778. (*Sir John Coode.*) I think Mr. Baldwin Latham said in answer to a question by myself, that he obtained those figures from the Thames Conservancy Record ?—Mr. Latham states in his report that the dry weather flow is 12 cubic feet per minute per square mile; my figure I know does not differ very greatly from that, though it may not be identically the same.

The witness withdrew.

(*Mr. Bidder.*) I have drawn my learned friend's attention to the passage in the evidence in which the sections are referred to—it is at Question 8904 Mr. Mansergh was asked, "You have given us a "certain amount of sectional areas of the river upon "the paper M 2; but you have cross sections of the "river all the way down, have you not. (*A.*) I had "134 plotted. (*Q.*) Have you any objection to pro- "ducing them all ?—(*A.*) I do not think so; my cross "sections as I explained are between something "above high water and something below low water," and then my learned friend Mr. Webster, as my learned friend reminds me, said "You shall have them "of course."

(*Mr. Balfour Browne.*) What I am instructed is that if my learned friend wants to look at what Mr. Mansergh used he is perfectly welcome to it; but if he wants us to plot them upon paper and hand in copies, I believe it would cost a very large sum of money to do it,

(*Mr. Bidder.*) I do not want to put my learned friend to any unreasonable trouble. I understood Mr. Mansergh to say they were all plotted, and all we want is to be able to have a copy of them or even to copy them ourselves—we do not want Mr. Mansergh to be at the expense and trouble of copying them.

(*Chairman.*) Do I understand you to make any application.

(*Mr. Bidder.*) I do not understand that it is necessary.

(*Mr. Balfour Browne.*) I will call the attention of my leader to it—Mr. Mansergh is not in town now-but I will bear it in mind and your attention shall be called to it again.

Mr. Peregrine Birch, called again and further examined.

(*Mr. Balfour Browne.*) When you were cross-examined by my learned friend Mr. Michael, there was a discrepancy pointed out. I do not know whether he wants to ask you any further questions.

*Mr. P. Birch.*

(*Mr. Michael.*) Not just at present.

9779. (*Mr. Balfour Browne.*) Will you explain the discrepancy ?—There was a discrepancy between the number of days in which I made it appear necessary for the sewage to pass through a certain section of five miles, and the time which appeared from Mr. Mansergh's tables to be required for it to pass through the same five miles.

9780. (*Chairman.*) Will you give us the reference; is it at Questions 9351 and 9352 ?—That had reference to the five miles below Crossness. Mr. Michael says after question No. 9351. "No; I make it that there "is about 100,000,000 difference between us." That was so, that there was about 100,000,000 difference between us.

9781. (*Chairman.*) Which is the discrepancy which you wish to explain ?—It is that as I mentioned upon the last occasion, certain of these daily divisions were calculated, and the intermediate ones were filled in without being calculated; the one was calculated, and that would be accurate—the others were filled in by the eye. The five miles happened to begin and end at certain points between the calculated points, so that a very small correction of the intermediate ones will make the difference. The division between September the 3rd and September the 2nd upon that diagram was calculated; the division opposite Erith was calculated; no other was calculated until you come to the division between the 20th and the 21st of August.

(*Mr. Michael.*) The inaccuracy did not matter as to any particular division because I have calculated every single one, but as I understood from Mr. Birch it was impossible to make them agree, because he had adopted a different principle from Mr. Mansergh. Both Mr. Mansergh and Mr. Latham had taken the quantity of water passing over Teddington Weir upon a particular day. Mr. Birch had adopted the plan of taking the mean of the quantity spread over 12 days as representing the quantity for calculation as the basis for that particular day, so that there must be a divergence.

(*Witness.*) But the discrepancy is not due to that at all. I did not take the mean of the flows at all. I took the actual flows of the days which contribute to or affect the diagram. I had nothing to do with any mean at all.

9781*a*. (*Mr. Balfour Browne.*) What does account for the discrepancy ?—The discrepancy is due to the intermediate divisions being interpolated by the eye and not accurately interpolated. If you get half a day out upon each side, that makes a difference of an addition or a deduction equal to a day's flow.

9782. (*Mr. Michael.*) But you will recollect that I added up the whole of the column and that showed a difference of at least 10 per cent. upon the whole ?—That I will explain by and by.

9783. (*Mr. Balfour Browne.*) Taking every tenth division, and comparing that with Mr. Mansergh's, there would be an absolute coincidence ?—Yes, taking these five miles. I find that by calculating an intermediate one, I make it that my total of five miles comes to 953,000,000, and Mr. Mansergh's comes to 955,000,000—those are the figures as given by Mr. Michael. I can show Mr. Michael a tracing which shows the adjustment.

9784. How do you deal with the question which my learned friend Mr. Michael has just raised, that the totals of Mr. Mansergh's columns were different from your totals ?—The total difference was not so much as 12 per cent.

(*Mr. Bidder.*) Yes, as 73 is to 82; the total of your columns added up, comes to 707,200,000, and the total of Mr. Mansergh's columns added up, comes to 825,611,870.

(*Witness.*) That is between Crossness and Southend.

(*Mr. Michael.*) Of the total divisions.

*Mr. P. Birch.*

20 Feb. 1883.

(*Witness.*) Of Mr. Mansergh's six lengths of five miles?

9785. (*Mr. Bidder.*) You both end at Southend?—Yes; but we do not both begin at Crossness. I think you will find that the 12 per cent. error is due to the column between Crossness and Southend.

(*Mr. Michael.*) No, the figures are all different.

9786. (*Mr. Balfour Browne.*) Just taking Mr. Mansergh's figures, is it the fact that he has taken a longer length of river than you have?—Yes, I find that he has divided the river into six lengths of five miles, and taken out his quantities accordingly, and I have taken the length from Crossness to Southend a little over 29½ miles, and that would no doubt make a little discrepancy, but I should say, that when I found I was within 5 or 6 per cent. of Mr. Mansergh, and that my error was favourable to the Metropolitan Board of Works, I considered that as we had arrived at the thing by two not identical processes, I had arrived at it near enough. I must emphasize the statement, that my error is in favour of the Metropolitan Board of Works; if it had been the other way, I should have taken more pains to get at the bottom of it.

9787. You took 29½ miles and Mr. Mansergh took six divisions of 5 miles each?—Yes.

(*Mr. Bidder.*) But that could not make a difference of 12 per cent.

9789. (*Mr. Balfour Browne.*) What difference would that make in the number of days in getting out to sea?—I have refined upon mine as far as ever I can. I could make it a day and a half longer; that would be the effect of the revision of all my calculations, to make it a slightly longer time going from Barking to Southend.

9789. And as you made it a day and a half shorter, that was all in favour of the Metropolitan Board of Works?—Yes; if my discrepancy had been the other side, I should have gone into it.

9790. You made it in your original calculation go out a day and a half quicker?—Yes.

*Mr. Michael* stated that he did not propose further to cross examine the witness.

(*Mr. Balfour Browne.*) Then there was a question about the floats.

(*Mr. Bidder.*) Cannot you let the unhappy floats die?

(*Chairman.*) Any question you have to put to the witness, please put it at once.

(*Mr. Michael.*) The witness was in charge of certain experiments, and he promised to procure certain information; it is not a matter of examining him now.

(*Chairman.*) Will you state whatever you have to put before us?

(*The witness handed a paper to Mr. Michael.*)

(*Witness.*) Mr. Michael put it to me, that some man of ours was supposed to have done wrong about 1 o'clock in Erith Reach, on the 16th of October. I have ascertained the name of the man, but I have not the charge that was made against him. I have seen the man and he denies all knowledge of having done anything wrong.

(*Mr. Michael.*) But I made no charge whatever. I said to Mr. Birch, "Were you in charge of these experiments"? and he replied "I was"; then I said, "Do you know the men who were employed"? and he said, "I cannot charge my memory, but if you will "give me any specific question as to any man em- "ployed upon certain occasions, I can tell you who "they were, and when they were employed." I presume Mr. Birch will now give me the information who was in charge of a certain float at a certain time and place.

9791. (*Chairman to the witness.*) Are you able to supply these names and places?—I am.

After a short discussion.

9792. (*Mr. Michael.*) The question I asked was the name of the man in charge of the float that passed down Erith Reach upon the 16th of October?—It was in charge of men named Warner and Britchler; that was No. 4 float.

9793. Were Meares and Whiting employed upon October the 17th, at 6.15 a.m.?—Yes, they were.

9794. Where were they at that time; do you know of your own knowledge?—I do not know, but I can get the information for you.

9795. Who were the men in charge of No. 6 float, near Millwall, on October the 16th?—There is no time mentioned, so that may refer to two men named Long and Hampshire, or to two men named Wright and Arnold.

9796. What time were the first two men employed upon No. 6 float, and what time of the day were the second two men employed?—Wright and Arnold were occupied the first 12 hours of the day, and Hampshire and Long the second 12 hours of the day.

9797. (*Sir John Coode.*) When you say the first 12 hours, you mean from midnight to noon I suppose?—Yes, I suppose so, but they divided their work differently.

(*The witness referred to a time sheet.*)

9798. What No. of float were Tanner and Long employed upon, on October the 29th at 5.50 a.m.?—No. 6 float.

9799. And which float were Taylor and Clements employed upon, on October 30th at 5.17 a.m.?—That was No. 1 float.

9800. (*Mr. Lumley Smith.*) To make it intelligible upon the notes, this paper upon which my learned friend has been examining you, was supplied to you since the last meeting of the Commission?—Yes.

9801. It asks you, does it not, certain definite questions as to certain men, and where they were at work?—No, it does not ask very definite questions, and that is why I took the trouble to find out things which had not been asked.

9802. No charges were made upon that paper?—No, I sent down to inqure of the men yesterday, and could not find anything of the kind.

9803. During the time the experiments were going on, was any information ever given to you by my learned friend's clients of any misfeasance on the part of the men?—Certainly not.

9804. They were a public body and they gave you no reason to be dissatisfied with your men?—No.

9805. Have you made any inquiry——

*Mr. Bidder* objected to the question.

*The Chairman* intimated that this branch of the examination was wide of the main question.

(*Mr. Lumley Smith.*) I propose to put the following questions to the witness. Have you made every inquiry with the further information which is given you by my learned friend's clients, and have you any reason to believe that there has been any misfeasance on the part of your men.

*Mr. Bidder* objected to the question.

(*Chairman.*) If it were in any way material, we should form our opinion upon the tangible evidence which came before us.

(*Mr Bidder.*) I am bound to tell my learned friend that the reason we have asked these questions in the case of these men arises from a discussion which took place upon the previous occasion. I told my learned friend then, that if he relied in any way upon these float experiments he must prove them. Mr. Birch had the general superintendence of them, but Mr. Birch could not be present upon every occasion with the floats, and if my learned friend relies upon these floats, I am bound to tell him that I shall prove at the proper time that they were doing things which they ought not to have done.

(*Chairman.*) Surely it would be time enough to make that observation when you came to make your opening speech, but still you have mentioned it, and we can deal with it if it should hereafter become necessary.

The witness withdrew.

Dr. Charles Meymott Tidy, M.A., M.B., called; examined by Mr. Lumley Smith.

*Dr. C. M. Tidy, M.A., M.B.*

20 Feb. 1883.

9806. I believe you are Professor of Chemistry and Forensic medicine at the London Hospital?—I am.

9807. I believe you hold several other offices?—I do.

9808. You have had for some years, have you not, considerable experience in Parliamentary Committees and elsewhere upon matters connected with water, and water pollution in the river Thames?—Yes, I should say I have had considerable experience.

9809. Before proceeding to matters of greater detail I am going to ask you a few general questions with regard to the composition of the water of the Thames; what will be a convenient way in your judgment of dividing the subjects? The river Thames is composed of various elements of course?—It is composed of river water pure and simple, of sewage, and of sea water, and it occurs to me as convenient to take in the first instance the character and the composition of those three classes of water, and then we can deal with them when we get to the mixture.

9810. When you speak of the Thames water pure and simple, I presume you refer to the water which comes over Teddington Weir; whether it is either really pure or simple is another question?—That is quite another question.

9811. Now what opportunity have you had of becoming acquainted with the water of the Thames which comes over Teddington Weir?—I cannot say that I know the water exactly as it comes over Teddington Weir, but I know the water of the Thames from a very long series of observations at the intake of the London Water Companies at West Moulsey, and you may fairly take that as representing, and as a matter of fact I know it does, the composition of the water as it comes over Teddington Weir.

9812. I presume you have had to make those investigations partly with regard to the supply of water to the metropolis?—Yes, I have had for many years past a sample of water taken from the middle of the river one foot from the surface upon the 15th day of each month.

9813. Then for all practical purposes we may take the water at West Moulsey as practically the same as that in the rest of the river at Teddington?—Yes, the samples extend from 1874 to 1879. I have put down in a table the quantity of matter in solution and the quantity in suspension during that period. There were a few lapses between 1874 and 1879. The reason why I have omitted certain samples is, that those samples were taken at some other period of the month, some were taken upon the 3rd of the month, and some were taken upon a later date, so I have only selected those samples only which were taken upon the 15th of the month.

(*The table was handed in and was as follows.*)

## TABLE.

Table showing Dissolved and Suspended Matters in Samples taken from the River Thames at Hampton, about one foot from the Surface, on or about the 15th day of each Month.

| — | 1874. | | 1875. | | 1876. | | 1877. | | 1878. | | 1879. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Dissolved Matters. | Suspended Matters. | Dissolved Matters. | Suspended Matters. | Dissolved Matters. | Suspended Matters. | Dissolved Matters. | Suspended Matters. | Dissolved Matters. | Suspended Matters. | Dissolved Matters. | Suspended Matters. |
| | Grains. | Grains. | Grains. | Grains. | Grains. | Grains. | Grains. | Grains. | Grains. | Grains. | Grains. | Grains. |
| January | — | — | 21·40 | t. | 22·70 | t. | 21·10 | 1·26 | 23·00 | 1·46 | 22·40 | 0·84 |
| February | — | — | 21·17 | 0·64 | 22·80 | t. | 21·00 | 1·11 | 21·80 | v.s.t. | 21·10 | 0·31 |
| March | — | — | 21·21 | 1·21 | — | — | 21·50 | 0·84 | 21·80 | c. | 21·20 | 0·21 |
| April | — | — | 19·88 | 0·22 | — | — | 19·40 | 0·21 | 19·30 | c. | 21·00 | 0·26 |
| May | 17·15 | v.s.t. | 19·29 | 0·18 | — | — | 17·50 | v.s.t. | 19·60 | c. | 21·20 | 0·30 |
| June | 17·63 | t. | 18·48 | s.t. | — | — | 18·20 | v.s.t. | 20·50 | c. | 20·50 | s.t. |
| July | 17·23 | t. | 18·04 | t. | — | — | 17·60 | v.s.t. | 17·60 | c. | 22·20 | 1·00 |
| August | 16·98 | t. | 19·20 | s.t. | 17·50 | 0·34 | 19·50 | v.s.t. | 18·30 | c. | 22·00 | 0·64 |
| September | 16·99 | c. | 19·30 | s.t. | — | — | 21·00 | s.t. | 20·60 | v.s.t. | 21·00 | t. |
| October | 17·13 | t. | 20·13 | 0·24 | — | — | 19·90 | c. | 19·90 | 0·24 | 26·00 | 0·23 |
| November | 19·62 | t. | 21·27 | 1·18 | — | — | 20·00 | 0·21 | 23·00 | 0·51 | 22·00 | 0·27 |
| December | 19·90 | 0·02 | 21·70 | 0·63 | — | — | 22·20 | 1·24 | 24·30 | 0·46 | 22·00 | t. |

c. = *clear*; that is, where there is no visible suspended matter.
v.s.t. = *very slightly turbid*; that is where a few floating particles are perceptible.
s.t. = *slightly turbid.*
t. = *turbid*; that is, where the quantity of suspended matter is less than 0·1 grain per gallon.

9814. It may seem perhaps an elementary question, but what have you to consider with regard to the water; you mentioned the solid matter; that appears I presume either in solution or in suspension?—Yes, that is so.

9815. What are the divisions of what is in solution; may that again be sub-divided?—Very much so.

9816. Then what classes would the matter in solution divide into?—It may be divided of course into the organic matter and into the mineral matter.

9817. The mineral matter speaks for itself, but what do you call the organic matter?—The matter derived from vegetable or from animal substances.

9818. With regard to the matter in suspension there, I presume you get a still greater variety?—There again you have only the mineral and organic.

9819. Then shall we begin with the solid matter?—May I say, with respect to the analyses in this table, that all that was done with this water and which is recorded here was as to the dissolved matter and the suspended matter in each sample. So far as the composition of the mineral matter is concerned, that is derived from an examination of the filtered Thames water as supplied by the several companies.

9820. You have not actually filtered the sample that was sent to you?—With respect to the water that is taken from the river itself, the only two things that were estimated were the dissolved matters, and the suspended matters. With respect to the actual composition of the water, that has been the result of a a series of analyses of the filtered Thames water itself, and therefore this diagram refers simply to the quantity dissolved and the quantity of suspended matter in the samples taken a foot from the surface, upon the 15th of each month; but the composition of the water in greater detail refers to the other samples as well. Now during these years from 1874 to 1879, the suspended matters in the water of the Thames were estimated upon 59 different occasions; on eight occasions the water was found perfectly clear; on seven occasions it was found "very slightly turbid"; what that really means is, that one sees minute particles but you cannot estimate it. On five occasions it was noted as "slightly turbid;" those of course are arbitrary terms, but the latter means something that appears to me more than "very slightly turbid." Then on 11 occasions it was found to be turbid, and I think I may say this, that when the water is marked as "turbid" it contains less than, or somewhere about one-tenth of a grain of suspended matter per gallon. Upon eight occasions it was found to contain less than a quarter of a grain of suspended matter per

*Dr. C. M. Tidy, M.A., M.B.*

20 Feb. 1883.

gallon; that is to say, between a tenth and a quarter; upon six occasions it was found to contain between a quarter and a half a grain per gallon; upon five occasions between a half and three-fourths; on three occasions between three and a quarter and one grain; and on seven occasions above one grain of suspended matter per gallon. The analyses were not continued for this purpose after the year 1879, and therefore I am not able to give you any further details.

9821. What do you say as to the average of the river with regard to the suspended matter; first of all does it vary much with the time of year?—It does vary a good deal according to the quantity of flood water; but the point which this table seems to suggest is, that the quantity of suspended matter in the River Thames above Teddington, that is to say, the water taken at Moulsey is exceedingly small, and that as a matter of fact, the turbidity of the water may be due to an almost inappreciably small quantity of suspended matter. It is wonderful the very small quantity of suspended matter that will make the water appear perfectly turbid.

9822. Then practically you give the water a good character?—Yes, I give the water a good character as as far as the suspended matter is concerned.

9823. Now taking the soluble matter, that is to say, matter in solution, will you give the quantities?—The total solid matter in solution in Thames water varies from 17 to 22 grains per gallon, occasionally it is a little below 17 grains per gallon, but I never knew it below 16 grains per gallon, and in the other extreme, it is occasionally a little above 22 grains per gallon, but not above 23 grains, so that practically the extreme limits may be taken as from 16 to 23.

9824. Do you find that that varies at different times of the year?—Yes, it does. The quantity of dissolved matter in the water of the River Thames shows a perfectly well defined wave in the course of the year.

9825. At what time of the year do you find that there is the greatest quantity?—It always reaches its maximum, that is to say, the crest of the wave occurs about February.

9826. (*Mr. Bidder.*) Your highest is marked in December?—Those are the actual numbers. I am taking now the average of a very large number of experiments, you only get the wave properly by taking a very large number of experiments. I am speaking of the dissolved matter in filtered water.

9827. (*Mr. Lumley Smith.*) Have you worked this table from the filtered water?—I have worked this table from the filtered water entirely.

9828. As my learned friend Mr. Bidder points out, you do find on one occasion as much as 24·30?—That is the unfiltered water.

9829. When you are telling us about your general conclusions, those are derived from the filtered water?—Yes, the water of the water companies.

9830. But you say you find your highest amount of dissolved matter is in February?—Yes, and the smallest amount invaribly occurs in August taking a very large number of results, it forms a perfect wave from February to August, and then from August to February; that is to say, the dissolved matter in filtered water.

9831. I presume the same law would apply very much to unfiltered water?—Yes, in a great measure, but there is something taken out by filtration beyond the mere suspended matter.

9832. For our purposes we shall have to deal with the actual water rather than the filtered water?—Yes.

9833. This table you have here is taken from the actual water of the river unfiltered?—Yes, when the suspended matter has been allowed to deposit, and then the clear water has been syphoned off and the total solid matter estimated.

9834. Now with regard to the chlorine found in the river, what may that be taken at broadly?—In the Thames, as the result of a very large number of observations, it may be said that one grain of chlorine per gallon is the normal quantity. It may be taken that from February to August, the quantity of chlorine in the river is about one-tenth above one grain, and from September to January one-tenth below one grain per gallon.

9835. Then roughly the quantity may be taken as rather more than a tenth of a grain per gallon from February to August?—Yes; and from September to January a tenth of a grain less than a grain.

9836. What is the presence of chlorine due to, because there is no sea water up there?—It is very difficult to say, all river water, indeed all water contains a certain small quantity of chlorine.

9837. Is that common salt?—Yes, it is there as common salt.

9838. We have now dealt with matter in suspension and matter in solution, would you now come to the organic matter, which is a sub-division of either I presume?—It is part of the solid matter of water, that is to say, when you speak of matter in solution, that means both the organic and the mineral.

9839. For the purpose of considering the purity of the Thames water, is it necessary to consider the mineral matter?—I do not think it is important, or rather I should say not the general constituents. The chlorine is important undoubtedly, and the total solid matter is important, and the magnesium is of a certain importance.

840. With regard to the organic matter, that is important, is it not?—Yes.

9841. What can you tell us about the organic matter in the Thames water at Teddington?—I have been working with Dr. Frankland in this matter, and I have quite agreed with him that it was advisable to adopt one method of examination throughout, and I am equally convinced that the only mode by which we could have estimated the organic matter in the water, is by the process which he himself suggested—the combustion process—that is to say, by the estimation of the organic carbon and of the organic nitrogen in the water. I am perfectly conviced in my own mind that it is the only process which in this special case would have give us accurate results.

9842. If that is a process which has been arrived at after consideration by Dr. Frankland, would it be desirable to describe a little more in detail what you did?—I scarcely think it is necessary, though I should be very happy to do so, but I would say that having myself suggested the process of estimating the oxygen required to oxidize the organic matter, it would seem strange that one had not introduced that into one's tables. The process is not applicable with so large a quantity of chloride of magnesium as one had to deal with in this special water where we have a large quantity of sea water, so for that reason I have not adopted it in these tables. The second process as regards albumenoid ammonia as it is called, is I am quite certain, a process which gives no results upon which one can rely in any way, therefore one was thrown back upon what I believe to be the only process which was applicable in this special case, and that was by the actual combustion of the residue, and the estimation of the organic carbon and the nitrogen.

9843. Which order would you take them in first, the organic carbon or the nitrogen?—I do not think it would make very much difference in this reach of the river in considering the normal character of the Thames water. I would say that the total quantity of the organic matter varies somewhat with the time of year; manifestly as we should have expected. For instance taking the year 1881, (and the same thing is practically true of 1882, but I have worked out the year 1881,) the organic carbon in the river water varied from ·072 to ·256 grains per gallon. Then the second point, which s very important, is the ratio of the nitrogen to the carbon, because, whilst the total quantity of the organic carbon and nitrogen indicates the total quantity of organic matter present, the ratio of the nitrogen to the carbon indicates somewhat the kind of organic matter present, that is to say, whether it is of animal or vegetable origin. Taking the normal

Thames water, it may be said that the ratio of nitrogen to carbon is about one to eight.

9844. Do you find that at all times of the year, or does it vary?—It varies somewhat; the variation would not be very great, but generally speaking it is as nearly as possible between say from 1 to $7\frac{1}{2}$ and 1 to $8\frac{1}{2}$. Then as regards the proportion of ammonia which is present in the Thames water, the quantity is very small indeed; I am speaking now of the water above Teddington. In the majority of the samples of the water there is none at all. Then sometimes one finds the thousandth of a grain, sometimes two thousandths of a grain, but the quantity of ammonia which is found in normal Thames water is for all practical purposes, nil.

9845. But does the ammonia come from the organic matter?—Yes.

9846. Speaking as an unscientific person, organic matter is a thing to be deprecated in water, is it not?—It very much depends upon the kind of organic matter. I do not know that there is any evidence to show that organic matter of a peaty origin is in the slightest degree injurious. For instance, in the Shannon, one of the purest rivers in the world, we find a considerable quantity of organic matter derived from the Irish peat bogs, but there we have a very low ratio of carbon to nitrogen, and there is no evidence to show that it is in the slightest degree injurious.

9847. (*Professor Williamson.*) I presume you have tested the water for nitrates as well as for ammonia?—I have.

9848. With what result?—I do not know that I can give it you at the instant, but I think it may be taken at from two-tenths to three-tenths of a grain of nitrogen as nitrates per gallon. Then another thing which will have a good deal of bearing upon our case is the question of the free oxygen in solution—the dissolved oxygen. One may say that it is only lately that we have had a practically easy method of estimating this dissolved oxygen, but for the last two years, I made seven determinations every day of the free oxygen in solution in the water of the Thames supplied to London. It varies somewhat according to the time of year; in other words according to the temperature. It is sometimes as low as one and seven-tenths of a cubic inch per gallon; but it may be said generally that the water of the Thames contains two cubic inches of free oxygen per gallon. It is sometimes 2·2, it sometimes goes down to 1·9, and even to 1·8 of free oxygen per gallon.

9849. (*Dr. Stevenson.*) Is that the filtered or the actual water of the river?—It varies very little indeed.

9850. (*Mr. Lumley Smith.*) I do not know whether you could tell me how many cubic inches there are in a gallon?—277.

9851. And you say there are about two cubic inches of free oxygen to a gallon?—Two cubic inches of oxygen at the standard temperature and pressure.

9852. Will you tell us what are the good and bad elements in the water. You told us with regard to your organic matter that they depended upon what it was; but with regard to the proportion of nitrogen to carbon, which of those elements in excess is pernicious, or what is the normal condition of purity, can you tell us that?—One can say this, that when the ratio of nitrogen to carbon increases, and one gets a very large quantity of nitrogen, it indicates animal rather than vegetable contamination, and so far as injury is concerned, undoubtedly, facts show that animal contamination is infinitely more dangerous than vegetable contamination, and that therefore the larger the ratio of nitrogen to carbon, the more polluted the water becomes.

9853. You get either nitrogen or carbon from animal or vegetable matter, but you get it in an increased proportion from animal matter?—Yes.

9854. Have you any remark to make as to the solid matter in solution in the upper Thames water?—No, nothing beyond what I have said. I would say, speaking about the Thames water, that the composition of the Thames water in the upper reaches above Teddington is fairly constant; I might say singularly constant, and I think it indicates water of a very considerable degree of purity. I would say about the suspended matter of the water, that the suspended matter of the water in the higher reaches is almost entirely of the nature of clay and of sand; it is nearly always clay and sand mixed with occasional particles of vegetable matter or fibre. It is a matter of fact that the suspended matter which is found in the higher reaches has a specific gravity of about $2\frac{1}{2}$; it is very finely divided, and is very long retained in suspension, but it may be taken to be of that composition as nearly as possible.

9855. It remains suspended a considerable time you say?—Yes, and although a thing may have a high specific gravity, if you sub-divide it, it does remain in suspension a considerable time, as Professor Faraday found when he sub-divided gold.

9856. Is there anything else which you wished to say with reference to the water above Teddington?—No, that is all I have to say about that.

9857. (*Dr. Francois de Chaumont.*) How do you determine the quantity of free oxygen in the water?—The quantity of oxygen in the water is determined by a modification of Schutzenberger's process; every tenth determination that we made for nearly two years was done actually in addition, in order to see how far it corresponded.

*Dr. C. M. Tidy, M.A., M.B.*

20 Feb. 1883.

Adjourned to to-morrow at half-past 12 o'clock.

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# TWENTY-FOURTH DAY.

## Wednesday, 21st February 1883.

PRESENT:

SIR P. BENSON MAXWELL, IN THE CHAIR.

COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.

WILLIAM POLE, ESQ., F.R.S., *Secretary.*

DR. CHARLES MEYMOTT TIDY, M.A., M.B., further examined.

21 Feb. 1883.

9858. (*Mr. Lumley Smith.*) You gave us yesterday your account of the upper Thames water, and I propose now to ask you some questions with regard to the sea water and the sewage, but before I come to that I notice that in what we are coming to you have given your quantities of carbon and nitrogen in parts per 100,000?—That is so.

9859. You gave it us yesterday in grains per gallon,

*Dr. C. M. Tidy, M.A., M.B.*

21 Feb. 1883.

and it may be convenient that you should give us, if you can, with regard to the Thames water, what is the quantity of carbon and nitrogen per 100,000 parts?—I will. The organic carbon varies from ·103 to ·364 in the 100,000 parts. I think, myself, that the ·364 is rather high, but still it does vary between those numbers.

9860. And the nitrogen is an eighth of that?—The nitrogen is an eighth of that.

9861. I believe you mentioned yesterday that the suspended matter formed a wave?—The total solid matter. I would just say that I have here a diagram which gives the average results of something like 1,200 analyses of the filtered Thames water. It shows that the highest point, that is where the total solid matter is at its maximum is in February; it gradually decreases in a perfectly regular wave to August, and then it goes up again to February, so that the total solid matter in normal Thames water is one complete wave every year.

9862. Now we will pass if you please to the sea water, we will take that before we deal with the sewage, we have the Thames water at one end of the river, and now we will go to the sea water which we meet with at the other end?—The composition of sea water has been examined by us lately upon a great many occasions. (*The Witness here handed in a collection of Tables and Diagrams. See Appendix A.G.*) The results which have been arrived at by us confirm almost entirely those which have been arrived at by the Rivers Pollution Commission, and mentioned in their Sixth report.

9863. Can you give us the reference to that?—I cannot at the moment, because I have not the Sixth report with me, but I dare say Dr. Frankland can. Many of these samples were taken by myself, some were forwarded, and there is one which I have put in of the Dead Sea which is interesting in itself, which I did not take myself, but which is well authenticated.

9864. The curiosity in that case is, is it not, that the nitrogen actually exceeds the carbon?—Yes, the great peculiarity to be noticed first of all with regard to the organic matter in sea water is, the very large quantity of nitrogen that it contains, that is to say, the ratio of the nitrogen to the carbon. Thus out of these 15 analyses, in three the organic nitrogen was in actual excess of the organic carbon. That occurs, for instance, in the Dead Sea to a most remarkable degree; we have ·3 parts in 100,000 of organic carbon and ·4 of organic nitrogen.

9865. You told us yesterday that in Thames water the nitrogen is one eighth of the carbon?—Yes.

9866. In all sea water, the nitrogen is at a very much higher ratio?—A very much higher ratio, it may be taken at somewhere about one to one-and-a-half. The fact is, that in sea water, when the organic matter gets into the sea, the carbon is far more easily oxidized than the nitrogen, and as the result of that, the oxygen gets concentrated on the carbon. It is not by any excess of the nitrogen, but it is by a decrease of the carbon.

9867. You mentioned that in some of the sea water near the Thames, the nitrogen was in excess of the carbon?—That is so.

9868. You find that, do you not, at Southend?—Yes, I find that at Southend. At low water on October 16th, the organic nitrogen was higher than the organic carbon.

9869. And also on one occasion in June?—On one occasion at high water in June at Southend, the same thing occurred. The next thing to be noted in sea water is that there is very little ammonia indeed, it may be taken in many samples as none at all, sometimes there is a 1,000th of a grain, sometimes 2,000th of a grain, and in one case only did I find a 100th of a grain of ammonia.

9870. You have told us that in the upper Thames water the ammonia is nearly nil?—Nearly nil.

9871. And in sea water it is also nearly nil?—Yes, in sea water also it is nearly nil.

9872. That will be of importance when you come to try to trace the sewage?—It will; the question of the ammonia will become an important one. Then another thing to be noted is the very small quantity of nitrogen as nitrates in sea water. Then there is another point to be referred to, and that is the quantity of free oxygen; it was not estimated in those samples; except in two of them in which it was estimated, but I examined the free oxygen in sea water daily, and sometimes more frequently for more than a month off the west pier at Brighton; as a matter of fact, there were over 50 determinations, and the quantity of free oxygen in the sea water there varied from 1·7 cubic inches to 2·1 cubic inches per gallon of free oxygen in solution; therefore, as a matter of fact, the sea water that spot agrees with river water in this, that it is well taken at oxidised. There was a case at Margate where it was found to be 1·656.

9873. That is the only one you have here?—Yes, the only one I have here.

9874. Comparing fresh water with sea water, we find that as to ammonia they are pretty much the same. As to nitrogen, there is an increase in the quantity of nitrogen in sea water. As to free oxygen in solution, it is pretty much the same, except that in sea water it is rather less.

9875. (*Dr. Stevenson.*) Do you mean that there is an absolute increase of organic nitrogen, or a relative increase?—A relative increase; it is the ratio that is altered.

9876. (*Mr. Lumley Smith.*) Now with regard to the chlorine, what have you to say?—With regard to chlorine there is no doubt that it varies considerably. I have given the proportions in the table of the chlorine found at different places, perhaps the Southend samples are the ones that are more especially interesting in connection with this case; they vary from 1,246 grains at low water, on October 16th to 1,558 grains at high water upon June 10th.

9877. What do you observe from that?—One finds that in nearly all the samples the total quantity of solid matter, and the total quantity of chlorine is greater at high water than at low water. There is an exception to that, and I really cannot explain it, in the case of Brighton in September 1882.

9878. I think that concludes, does it not, what you are going to tell us about the sea water?—I think that is all I have to say about that.

9879. We will pass on to the sewage—tell us first of all, if you please, what amount of matter in solution you find in the London sewage, what sewage are you taking for this purpose?—It appears to me impossible to compare the sewage of other places with London sewage, and therefore seeing what differences there are in various kinds of sewage, the only question of interest in this inquiry is London sewage, and not any other kind of sewage; therefore I limit myself entirely to London sewage, which I think will be more convenient. I do that because I regard sewage as a very complex body, varying according to the habits of people, that is to say, according to the kind of work that is done, the trade and manufacture that is carried on; varying also with the time of year and time of day and so on; but it appears to me that the only fair way to regard the question of sewage is to take a large number of samples of London sewage as the basis of comparison; but even then I must admit the difficulty. To begin with, I have looked up a very large number of experiments which were made, and in as much as I was engaged upon them myself during the time I was assistant to Dr. Letheby, I may refer to them. I have here the analysis of a gallon of sewage taken from ten of the large City sewers, I cannot give the precise places, but they were ten of the large City sewers, the average flow at midday from which is marked as 3,490 gallons per minute. It was during the time I was assisting Dr. Letheby as medical officer of health to the city, that those were taken.

9880. (*Mr. Bidder.*) During what year?— They were before the year 1875. Now taking mid-day sewage, there was an average of 94 grains of solid matter per gallon of which 56 grains were in solution

and 38·15 grains in suspension, of that 94 grains, 31 grains were organic, 15 grains of that organic matter were in solution, and 16 grains in suspension. Night sewage, again, varied somewhat from the day sewage, it did not contain so much matter in suspension ; and again storm sewage varied from both. Taking the general proportion of suspended matter in ordinary sewage, I think it is fair to say it contains about 25 grains per gallon of suspended matter.

9881. Is that London sewage ?—Yes, but that 25 grains does not include storm sewage, because it has been clearly shown, and I know it of my own knowledge, that storm sewage often contains an enormous quantity of suspended matter. I would just say that Dr. Frankland and myself have found over 100 grains of suspended matter in a gallon of storm sewage, and that the Chemist of the Metropolitan Board of Works upon the last inquiry, that is to say in the mud inquiry, gave evidence to the effect that he had found over 95 grains, if I remember rightly, per gallon of suspended matter in storm sewage.

9882. (*Mr. Lumley Smith.*) What do you take the ordinary average quantity to be ?—It is a very difficult thing to say what you get as the average, but taking the average of one's own results with the results obtained by the Rivers Pollution Commission, one finds they very closely agree ; and I would say, putting all storm sewage and other sewage together, from 45 to 50 grains per gallon would not be an excessive amount of suspended matter, that is taking into consideration the 95 grains per gallon which Mr. Keates found, and we have found over 100 grains per gallon, and some samples recorded by the Rivers Pollution Commission are much higher than that ; so I venture to think that if you take all sewage together, day sewage, night sewage, strong sewage, and weak sewage, something like that quantity would express fairly what the suspended matter of the sewage is.

9883. (*Dr. Stevenson.*) By the 25 grains you spoke of, do you mean exclusive of the storm sewage ?—Yes, exclusive of the storm sewage. I take it that as the normal quantity from 23 to 25 grains may fairly be put down ; but taking all the rest of the year I doubt if it would come out at less than from 45 to 50.

9884. (*Chairman.*) That would include the storm sewage ?—Yes. In the report of the Rivers Pollution Commission we have a sample containing 164 grains per gallon, and I have myself found more than that, so I do not think we are taking an excessive quantity. The average of the samples given by the Rivers Pollution Commission is 48·5 grains, and when you take that an conjunction with Mr. Keates' experiments upon the A. B. C. process and in conjunction with one's own experiments, I do not think that from 45 to 50 grains on the whole is at all an excessive estimate.

9885. Is the storm sewage the same as other sewage ?—There is a great deal more mineral matter in it. I think the reason why the storm sewage contains so much more suspended matter than other sewage is, that there is always the road washing brought down in large quantities, and there is also a large quantity of matter which has accumulated in the pipes which is dislodged by the flow.

9886. It is scoured out ?—Yes. Then as regards the composition of ordinary London sewage—

9887. (*Mr. Lumley Smith*). Are you going now to the quantity of grains of matter which go into the Thames ?—I am going now to the composition of London sewage.

9888. Is that more germane to the suspended matter than the matter in solution, or would you give us the figures of the matter in solution before you come to that ?—I have very little more to say about the matter in suspension than what I have said, I think I have said all that is necessary. Now as regards the matter in solution, the strength of sewage will vary very much according to the time of the day ; for instance, there is a time when it is strong, and there is a time when it is weak, but as regards the organic carbon and the organic nitrogen as an index of the organic matter, the organic carbon as a rule as a maximum is about 5·4 per 100,000 parts, and as a minimum 3. I think you may take it that our results give about 4·3 as the average organic carbon in 100,000 parts. The organic nitrogen ranges from about 3·8 to 1·3 and about 2·5 may be taken as the average of organic nitrogen per 100,000 parts.

9889. You have given it in parts per 100,000 ?—In the organic nitrogen and carbon, I have taken it in parts per 100,000, and in all other cases at grains per gallon.

9890. Then the ratio of nitrogen to carbon is as 1 to 1·77 ?—Yes.

9,891. That is very different from what you find in the pure water ?—It is very different.

9892. It is more like what you get in sea water ?—Yes, it is more like that.

9893. Now we come to the ammonia ?—The quantity of ammonia in sewage is large ; it varies from about 6½ grains to about 2½ grains. I give organic carbon and organic nitrogen in every case in parts per 100,000, all the other results I give in grains per gallon.

9894. (*Mr. Bidder.*) It would have been much more simple if you had adopted one uniform plan ?—I have always adopted this plan, taking the organic carbon and the organic nitrogen in parts per 100,000, and all the other results ; as I have just stated, in grains per gallon ; now I think you may say that 6 grains of ammonia per gallon is the extreme number, and that about 3 grains of ammonia per gallon is the average of a large number of samples, it is not the mean of those two numbers, but a fair average of a large number of samples.

9895. (*Mr. Lumley Smith.*) That is grains per gallon ?—Yes.

9896. Now take the chlorine ?—The proportion of chlorine varies, but I think that from 10 to 11 grains of chlorine per gallon is the average of the chlorine in London sewage ; it does vary. I quite admit that you get quantities higher than that, and quantities lower, but I really think that from 10 to 11 grains is a fair average.

9897. Might I pause for a moment to make this general observation ; where you want to detect sewage in a mixture of pure water, sea water, and sewage, the only thing that seems peculiar to the sewage is the ammonia ?—The ammonia is decidedly one of the chief things.

9898. The increased ratio of the nitrogen and and carbon is common both to sewage and sea water ?—That is so.

9899. But the one thing that seems peculiar to the sewage is the ammonia ?—There is one thing which I will point out hereafter, and that is the quantity of free oxygen dissolved. It would be convenient to take that afterwards, as I shall have a great deal to say about that. I should like to add that it appears to me, as far as I can make out, that about 80 per cent. of the London sewage is represented by the water supply.

9900. (*Dr. De Chaumont.*) In the tables before us of the London sewage, the chlorine has been taken at 10 parts per 100,000, the quantity you have given us is somewhat above that ?—I think, in point of fact, the quantity of chlorine, though it varies considerably, yet it very often does reach 10 parts of 100,000, but that really makes very little difference.

9901. (*Mr. Lumley Smith.*) You were going to tell us something about the composition of the London sewage, and what went into the Thames ?—I was going to say that about 80 per cent. of the London sewage appears to me to be represented by the water supply, that is to say, if you take about 37 gallons per head as being the water supply, that would represent about 80 per cent. of the sewage ; it is 10 parts per 100,000.

9902. (*Dr. Stevenson.*) Is that your own observation, or are you taking the figures from others ?—It is my own observation, and it is not alone mine but it agrees with the observations of the Rivers Pollution Commission.

9903. (*Mr. Lumley Smith.*) You have made some

*Dr. C. M. Tidy, M.A., M.B.*

21 Feb. 1883.

observations, have you not, as to the quantity of polluting matter that went into the Thames?—I thought it very important to get some idea of the quantity of polluting matter that went into the Thames, and I have endeavoured to get that as far as I can.

9904. Will you tell us your process?—I take first of all the fæcal matter that goes in, and see the quantity of that, and secondly the urine that goes in, and here I am depending upon others calculations, the calculations of Röder and Eickhorn; they are two great German authoritities, who calculate that every 100,000 people consist of 37,610 men, 34,630 women, 14,060 boys, and 13,700 girls. Now these were the first estimates made of the quantity of fæcal matter passed by 100,000 persons. There have been a good many investigations since then as to English people, and they agree very nearly although not absolutely with these. It may be said from a large number of experiments, that every person, regarding them as made up of men, women, boys, and girls, voids about 1,750 grains of fæces daily, that is a quarter of a pound.

9905. Does this include fœces and urine?—No, we are taking fœces alone, that is one quarter of a pound of fæcal matter daily. Now of that 75 or nearly 75 per cent. is moisture, so that it may be taken that the dry matter voided daily per head of the population is about 1 oz.

9906. (*Chairman.*) Is that avoirdupois?—Yes, avoirdupois. Now taking the population as 4,000,000 of people drained, it follows that the moist fæcal matter discharged daily into the Thames is 444 tons, and that the dry fœcal matter is exactly 111·6 tons, that is that every day there is about from 444 to 445 tons of fæcal matter discharged into the river at Crossness and Barking alone from the 4,000,000 of population. Now of that 111·6 tons of dry fœcal matter a little over 11 per cent., but just about 11 per cent., is soluble in water, so that it may be said that of that 111·6 tons something like a hundred and a half tons is insoluble and about 11 tons soluble.

9907. That hundred and a half tons of matter which is not soluble every day goes into the Thames, and must go somewhere, it must either be deposited or go out to sea?—That is so, so that we have a total quantity of 445 tons, we have the dry matter at 111·6 tons, and of that 111·6 tons you may take 100·5 tons as being insoluble, and that is every day. Now about the urine, the estimations of Messrs. Röder and Eickhorn on the urine passed from the 100,000 people very nearly agree with all other calculations, and according to their estimate, we have the quantity of urine passed per annum by 4,000,000 people as equivalent to 376,605,555 gallons, which is discharged into the river annually, which is equal to 1,681,274·8 tons per annum.

9908. You did not give us the moist fæces per annum, you gave it us per day; what is the figure per year?—It is 40,374 tons annually, that is the dry material.

9909. And the moist will be four times that, that is roundly 160,000 tons?—Yes; now it may be said that the dry solid matter of the urine per head of the population is as nearly as possible $2\frac{1}{2}$ ounces, and that brings it to the $3\frac{1}{2}$ ounces of solid matter discharged per head daily, which was given by Mr. Baldwin Latham; that is to say, the urine contains $2\frac{1}{2}$ ounces of solid matter, and the fœcal matter 1 ounce.

9910. (*Mr. Bidder.*) But part of that is in solution?—It is in solution but it is solid matter all the same.

(*Mr. Bidder.*) Except that what Mr. Baldwin Latham gave was in suspension.

(*Witness.*) Now this $2\frac{1}{2}$ ounces is made up of about one half of urea, and the other half of extractive and pigment and the mucus and of salts, now from that it follows that every day 4,000,000 people by their urine alone contribute to the pollution of the river 282 tons of polluting matter in addition; so that putting all that together we have daily contributed to the river $3\frac{1}{2}$ ounces per head of polluting matter, or taking the population at 4,000,000 we have 393·9 tons of matter thrown into the river daily, of which 100·5 tons are insoluble and 293·4 are soluble. That goes into the river every day, and that is an equivalent, I may say, to 143,591 tons of solid filth per year thrown into the river Thames absolutely undefecated or unpurified in any way, form, or kind.

9911. (*Mr. Lumley Smith.*) Now is the figure which you have last given soluble or insoluble?—That is everything.

9912. That includes what afterwards goes into solution?—That includes all; it is the total solid matter that I have given. Then it is important to note that that estimate does not include the other matters which make up sewage, such as the washing of public thoroughfare, the filth of kitchens, and of laundries, and the drainage of stables; and then we have to remember that every cow passes a quantity of urine containing a quantity of polluting matter 13 times as great as human urine, and every horse 20 times, it includes none of those things; markets, slaughter-houses, all trades and everything else would be in addition to the amount which I have given of something like 400 tons every day thrown into the river Thames.

9913. (*Dr. Stevenson.*) Have you any idea of how many cows and horses there are in London?—I have no idea; I only say that my calculations, take no cognisance of any of these things. Of horses there would be a very large number.

9914. (*Mr. Lumley Smith.*) Now with regard to the solid matter which goes into the Thames and which never becomes soluble, because we have heard it oscillates backwards and forwards for a time and then deposits, is there likely to be any chemical action with regard to that solid matter or what becomes of it in your view?—The insoluble matter which goes into the river floats about.

9915. In it likely to combine with anything?—Yes; it no doubt combines with alluminous compounds from the alluvial mud that would be raised by the tides and by passing steamers, and so no doubt would be carried to the bottom; I think the insoluble matter a very serious source of nuisance in the river Thames.

9916. Let us hear your view about the matter?—Because it undergoes putrefaction, and it is in putrefactive decomposition that we get a true nuisance. In the case of oxidation we do not get much nuisance, the products are not offensive, it is in the putrefaction where we get the nuisance.

9917. What is the state of the sewage which gets to the bottom?—It undergoes putrefaction as I have stated; the gases of putrefaction render it specially lighter, and as steamers come by it is stirred up, the gas is given off and down it goes again; then it putrefies again and the process is resumed.

9918. There is a certain amount of oxidation, is there not, due to its coming to the surface?—But it is owing to putrefactive decomposition that a nuisance arises. When it goes to the bottom the putrefactive gases develop, and then the stuff rises and you have the putrefactive and offensive gases given off to the air.

9919. And having risen to the surface and given off putrefactive gases, what happens to it?—Then, as I have stated, it sinks again, being weighted down again by the mud in suspension, and having putrefied again, is again stirred up by steamers as I have described.

9920. With regard to the soluble matter what have you to say?—That no doubt undergoes a series of changes; it undergoes oxidation as far as it can.

9921. Does that render the amount of oxygen in pure water a matter of any importance?—Yes; that is what we shall come to in the tables.

9922. As you find the quantity of oxygen diminish, so you find a less purifying power in the water?—Yes, the quantity of oxygen dissolved is an index of the purifying power of the water.

9923. Have you finished now what you proposed to tell us about the component parts of the sewage?—Yes.

9924. We will go then next first of all to the general inspection of the river. I am coming now to the matter which you have seen yourself with regard to the sewage, will you tell us what opportunity you have had of seeing what comes from the outfalls?—I have been on the river a great many times.

9925. Have you ever seen the sewage coming out of the outfalls?—Yes, I remember one occasion very definitely, it was on a very cold frosty morning, it was the 15th of November 1879 to fix the date Dr. Frankland and myself were on the river, when we saw a rapid stream of sewage which we calculated, or rather Dr. Frankland calculated, at something like from 20 to 30 million gallons flowing over the apron of the northern outfall at dead low water. The entire volume of the sewage as it came over owing to the amount of steam given off into the cold atmosphere looked boiling hot. We noticed from the bed of the river a bubbling up of gases, indicative of the most active putrefaction, and the smell that was given off was exceedingly foul. We noticed a similar thing going on on the same day even in Barking Reach. Such a condition as we noticed upon that one occasion on the 15th of November could only point to contamination with comparatively recent sewage undergoing decomposition.

9926. With regard to the bubbling up of gases, would that indicate putrefaction?—Yes.

9927. Sewage takes some little time to go from London to the outfalls, how soon in your judgment would putrefaction begin?—That I think is a very difficult question to answer, it has a long way to travel before it gets to the outfalls; I should not like to bind myself, but I think I should be within bounds when I say nine miles. And moreover sewage contains within itself a series of bodies of different degrees of putrescence, so that you would have putrefaction going on, and then you will have a point where putrefaction will stop; then a new series of bodies will begin to putrefy, and you will have again a point at which it will stop. You will therefore get different degrees of putrefaction depending upon the kind of body that is putrefied, so that a great deal will depend upon temperature, upon the rate it travels, upon the distance it travels, and so on; consequently I do not think I should be able to give an answer to that question in the way that I should wish.

9928. But I understand you to say the bubbling up of gas means putrefaction?—Yes.

9929. And that you say you saw going on at Barking Reach upon that day?—Yes, I am convinced from my inspections of the river upon that and upon other occasions that under certain conditions of water and under certain conditions of tide and so on a very great nuisance exists undoubtedly.

9930. With regard to the temperature, are you able to tell us anything about the degree of temperature that is required to cause putrefaction?—I do not think I could say exactly, because owing to the different kinds of putresible matters present they are influenced by different degrees of temperature.

9931. Now you have divided the river into lengths, I think, and I believe you take the first length from Teddington to Purfleet?—Yes. I would say that I thought it desirable to get a notion of the general composition of the river at different points from Teddington downwards, and therefore I thought it best to take a large number of samples at different parts of the river, those samples were taken, and now I will put them in as a diagram. (*See Appendix A.G.*)

9932. The majority of those samples were taken by yourself, I believe?—They were all taken by myself except two, namely, 35*a* and 44, those I think will be proved by somebody else, they were all taken I would say in the middle of the river a foot below the surface. I think it right to say where this table fails, because I am quite aware that there are imperfections in it. The samples were taken at the parts of the river indicated at different states of the tide. I would have much preferred to have taken all them at the same state of the tide, but that was impossible, so I have had them taken as they are at different states of the tide, they were all taken at a foot below the surface so as to avoid any impurities that were floating upon the surface. A bottle is lowered at the end of a pole a foot below the surface, and then the water is let in. Now, I have, in order to make this diagram clear, arranged it in the form of a wave (*handing in a diagram*). In addition to that, in order to get a notion of the state of the water at Chiswick it will be convenient for me to put in all these tables before I commence. I have a series of samples of water collected at Chiswick at different times of the day.

9933. You have adopted the same plan as you adopted before of taking grains per gallon except in the case of the organic carbon and organic nitrogen, and those you have given in parts per 100,000?—Yes. Now in order to see how you can systematise a large body of facts, I have arranged them in different sections, which I have also put in the form of a table, and as those are all connected with one thing, I will hand them in at once (*See Appendix A.G.*)

9934. You have taken five lengths of the river, from Teddington to Battersea; from Vauxhall Bridge to Deptford; from Greenwich to the Royal Albert Dock; then from Beckton to Crossness; and then from Erith to Purfleet. Now with regard to the diagram, all the results are stated in grains per gallon except the organic carbon and the organic nitrogen, which are stated at parts per 100,000, and the free oxygen, which is stated in cubic inches per gallon. I see at the top and bottom of your diagram A, there are certain numbers from 1 to 58?—Yes.

9935. Do those Nos. 1 to 58 correspond with the 58 Nos. on your first table that you have handed in of your analyses of samples?—Yes.

(*The witness explains the relation of the diagram to the table to the Commission.*)

9936. It would have been rather better, if I may suggest, if your five reaches had been marked in some different colours upon the wave diagram,—can you point out upon the diagram where they would come?

(*The witness did so.*)

(*Witness.*) The top line, that is to say the deep black line on the wave diagram, shows the organic carbon.

9937. Before you go to that will you explain what the Nos. on the left hand are, such as 0·1?—The Nos. on the left hand represent the quantities per 100,000 parts of organic carbon and nitrogen, and the figures at the lower part of the diagram cubic inches of free oxygen per gallon.

9938. You were explaining what the top line indicated?—The black line at the top represents the organic carbon. I wish to note that there are some points upon which there are dots upon these black lines, take for instance No. 12 on the wave diagram, that means that there is a small streamlet or river joining the Thames at that spot, and it is represented by a spot in a circle. It would be manifestly unfair to put the composition of the Thames so high as that, so I have put in a dot which represents the composition of the water which joins the main river.

9939. To put this in general language, you start at the extreme left of your diagram with Teddington?—Yes.

9940. The organic carbon seems to sink rather at No. 6; that would be opposite Richmond?—There are undoubtedly variations in the quantity of organic carbon, sometimes it is a little more, and sometimes it is a little less. I am not able to explain these discrepancies, but I think it fair in taking a reach to average all the results and see what we get.

9941. Then your first reach, that is to say from Teddington to Battersea, brings you down to No. 25?—Yes, No. 25.

9942. The carbon seems to be running up towards the end of that reach?—It is slightly, and upon the table I have put in showing the average analysis (Table II.) you have there the average quantities of organic carbon and organic nitrogen, the ratio of the

*Dr. C. M. Tidy, M.A., M.B.*

21 Feb. 1883.

nitrogen to the carbon; in the first example it means 1 to 7·7, and the quantity of free oxygen is also given The quantity of organic carbon in the first section is ·216, and the quantity of organic nitrogen is ·028 per 100,000 parts

9943. Where is that?—In the reach from Teddington to Battersea. The ratio of the nitrogen to the carbon is 1 to 7·7, and the quantity of free oxygen is 1·48 cubic inches per gallon in that reach. I would say that it is perfectly true that in all these analyses you will be able to find different places where there is more at one spot and less at another, and we cannot give you any account or explanation of that; but in averaging a series of results you in a great measure minimise such things as experimental errors, and, I am sorry to say, that there are such things, and then you are able to get a very fair view by taking a number of samples in this way of the average composition of the water.

9944. You gave in this first reach from Teddington to Battersea, the ratio of the nitrogen to carbon as about 1 to 7·7?—Yes.

9945. In the water which came over Teddington it was about 1 to 8, was it not?—I do not think there is much difference, practically, you may take it as the same.

9946. With regard to the free oxygen, do you find that the same?—No; and that is a very important point; the free oxygen below Teddington is reduced very nearly by 25 per cent., there is a larger quantity of organic matter in the water, but the free oxygen in solution is sufficient to preserve its purity, that is to say, the organic matter is not increased, but the free oxygen is decreased.

9947. Am I putting it rightly when I say that your view is that from Teddington to Battersea the water remains pretty well as pure as at Teddington, but it is at the expense of the oxygen?—Yes, the power of self-purification is lessened, and that is the main point to notice up to Battersea.

9948. It uses up the oxygen and the oxygen is about sufficient to keep it as pure as at Teddington?—Yes; there is of course a contest going on between the organic matter and the oxygen, the oxygen being sufficient to keep the organic matter down.

9949. There are tributaries coming in such as the Crane and the Brent, have you considered their relation to the Thames?—Yes, I have. It is quite clear that, although they are certainly for the most part more impure than the main river, they do not materially affect the main river, the quantity or the rapidity of oxidation is such that practically the river is kept pure. I might say that I have taken no other estimation of the organic matters present except the organic carbon and the organic nitrogen, for reasons which I gave yesterday.

9950. With regard to ammonia, do you find much of that?—The ammonia is very little altered.

9951. And the matter in suspension?—There is an increase undoubtedly of the matter in suspension, but I do not think there is very much to say about that. I should like to say that the matters in suspension in reach No. 25 average eight tenths of a grain per gallon.

9952. Now your second reach is from Vauxhall Bridge to Deptford?—The second reach is from Vauxhall Bridge to Deptford, Nos. 26 to 35.

9953. By "reaches" you are not speaking of the reaches of the river?—No, they are simply arbitrary divisions of one's own.

9954. What do you find in that reach?—There is in this reach a manifest increase of organic matter, the organic carbon has gone up from 216 to ·323, the organic nitrogen has doubled, it has gone up from ·028 to ·054, the ratio of the nitrogen to the carbon is as 1 to 6, and the free oxygen again is reduced to 1·3 cubic inches per gallon, that is to say, concurrently with the increase of the organic nitrogen and with the alteration in the ratio we have a diminution of free oxygen; it is not a great diminution, it is true, but it is manifest. It appears to me that in this reach we have a portion of the river where the call that is made on the oxygen is almost the very maximum that the oxygen can bear. As a result of that the maintenance of purity in this reach is manifestly a difficulty, and I have no doubt at times it is impossible, but at the same time it is always manifestly a difficulty. I would say that I attach a great deal of importance to maintaining full æration for water, because I am quite convinced that in effecting the purification of the river the half-inch of free oxygen in solution between 1·5 and 2 cubic inches is infinitely more powerful than the half-inch between 1 and 1·5, that is to say the dilution, as in a good many other things, will render the activity far less than the mere diminution of quantity; in other words, say, that if a river has two cubic inches of free oxygen per gallon, and a purifying power of four, a river which contains 1½ inches per gallon has nothing approaching a purifying power of three.

9955. Now take the third reach from your No. 36 to 42, that is to say from Deptford to the Albert Dock?—Here the water becomes manifestly less pure, the organic carbon is doubled and the organic nitrogen quadrupled as compared with the previous reach, the ratio of the nitrogen to the carbon is as 1 to 3.

9956. And the free oxygen is reduced to 0·7 of a cubic inch per gallon?—I think that indicates that owing to a continuous stream of impurity the normal purifying action of the river water is interfered with, and its power of reparation seriously lessened.

9957. The next reach is the Beckton to Crossness Reach, from No. 43 to 53?—There, of course as you would expect, where the sewage was being discharged we get a very large increase of organic impurity in the water, a material rise in quantity. Thus the organic carbon is ⅛th greater in amount than in the previous reach, and 340 per cent. greater than at Teddington, the organic nitrogen is about 1,000 per cent. in advance of the samples in the first reach. The ratio of the nitrogen to the carbon is 1 to 2·5, while the quantity of free oxygen is not very different to that in the previous reach, it is a little less, but nothing to mention it is about $\frac{7}{10}$ths of a cubic inch per gallon. The importance of that fact is, I think, this, that admitting all one has said about oxidation, which I admit to the full, this is not a case in which sewage is poured into a water that possesses a power of self-purification, but where, by a constant pouring in of sewage the self-purifying power of the water is practically reduced to a minimum:—in other words you have taken away from it its power of reparation.

9958. You find that the oxygen is the same as in the reach above, as if no urther purifying by oxidation had gone on?—It is almost reduced to a minimum. The fact is the water had been trying to keep itself pure, it had a struggle in the reach between Vauxhall and Deptford, and after it had passed that reach it could not do any more, its power was exhausted.

9959. This reach from Beckton to Crossness is the one which receives the two outfalls?—Yes.

9960. Your judgment, I think, is that we must not treat this sewage as poured into pure water?—Certainly not, it is not the admixture of sewage and pure water that is ærated, it is the addition of sewage to sewage, and therefore it comes under a totally different category from any question relating to oxidation. Then there is another thing that relates to that point. Of course I know very well you will hear much about the purifying action, and that what I wish to draw attention to is the fact that this is the addition of water to a water containing a very large quantity of common salt, and we know the preservative action of common salt. We have therefore two very remarkable conditions, firstly, an enormous quantity of common salt, itself an antiseptic, and, secondly, a water in which there is practically no oxygen which is capable of acting at all.

9961. The sewage therefore remains to a large extent in its original condition, it is not burnt up by the oxygen?—I would not say that none of it is, but practically that result is reduced to a minimum.

9962. (*Professor Williamson.*) I understand you to say you believe the activity of the oxygen in destroying the organic matter is not in direct proportion to the amount of it, so that if there are 2 cubic inches per gallon you believe they act more than twice as strongly as one would act?—Yes; but I did not give those numbers.

9963. Have you made experiments in relation to the truth of that observation?—I cannot fix the exact relationship, but I can say that the power of self-purification which water possesses when it contains from 1·5 to 2 is infinitely greater than it possesses when the quantity of oxygen it contains is from 1 to 1·5.

9964. You are certain that the operation of it is much stronger?—Yes.

9965. Have you facts to furnish in support of those observations?—I have not with me, but I have carefully studied the matter. I made the remark that four was more than equal to double two, but I was not quite prepared to say what it was equal to.

9966. (*Chairman.*) This is the result of your own experiments and observations?—I have made a great number of experiments from time to time upon the oxidation of water, but I would say that when you get to a quantity like half a cubic inch the purifying power is almost reduced to a minimum. (*To Professor Williamson.*) I am sorry to say the facts you wish for, of which I have some memoranda, are not tabulated, but I will have, or endeavour to have, it done.

9967. (*Mr. Lumley Smith.*) Now I find the River Ravensbourne coming in at the beginning of your third reach, does that bring in much water?—No.

9968. Is that a disturbing element?—No; as a matter of fact I think I may say the Ravensbourne is purer than the main river.

9969. Now you have gone below Crossness?—Yes, I have gone to Erith and Purfleet; and I can only put the facts before you as to that reach. The organic carbon is ·718; the organic nitrogen ·176; the ratio of nitrogen to carbon 4·0 and the quantity of free oxygen ·508 cubic inches per gallon. What is the exact meaning of that alteration of the ratio of the nitrogen to the carbon I am sorry to say I cannot at the moment explain. I can only speak of the fact, I am sorry for the variation, because in all one's other observations there has been a certain amount of uniformity.

9970. (*Professor Williamson.*) Have you determined the ammonia?—Yes.

9971. What becomes of the nitrogen which is separated from the ammonia in the lower reaches, is it present in the form of nitrates or ammonia, or have you traced it?—I cannot say that I have, but I would say that if you refer to the ammonia column in the large table you will find the ammonia throughout given; but then there is another thing to be said about that ammonia which is this. I have not made a great deal of it for this reason, and that reminds me of another thing, that when you bring a sample home there is no doubt that the estimation of ammonia is not a very accurate thing, more especially for instance if you keep it a certain time. And there is another thing I would venture to say with respect to the estimation of free oxygen, there is no doubt that the estimation of free oxygen would be very much better made on the river itself; but as a matter of fact I have found that by taking a bottle quite full and putting the stopper in close upon the water so as to avoid any shaking about of the water, if the estimation is made within a short time (and I always make a point of having it made the following morning when the bottle is opened) I find it comes right within the second place of decimals.

9972. (*Professor Williamson.*) How do you manage to have your bottles filled with water, is the air in them displaced by the water?—The air is displaced by the water, at any rate they are all taken under the same conditions, it would be difficult to follow any other course.

9973. Unless you had a circulation of water through the bottle?—You might have that, but the bottle is practically lowered a foot below the surface and filled, and then the stopper is put in when the bottle is absolutely full.

9974. So that it displaces some of the liquid?—Yes; I find that if the estimation is taken within a short time it is very little altered, but if you have a quantity of air in the bottle and you allow it to tumble about, you do get an alteration.

9975. (*Dr. Stevenson.*) You mentioned the Ravensbourne, now I observe a considerable jump in your diagram at that point, can you attribute that to any cause beyond the Ravensbourne?—I cannot, because if you look at the quantity of organic matter in the Ravensbourne it is less than in the main river; but I should like to say that I did not take the sample of the river Ravensbourne, that is one of the two which I did not take.

9976. (*Mr. Lumley Smith.*) With regard to those little round circles which are put in as representing the contributory streamlets, are they put at such a height as to represent the amount of carbon or nitrogen of that river?—Yes, they are.

9977. Then taking your river Brent, which is on No. 12, the amount of carbon in that is greater than the amount in the Thames?—Yes, it is.

9978. It makes a considerable jump, but I see it does not cause very much difference in your wave?—No, but it is a curious thing, and it is worth noting, that the spot where the rivers Crane and Brent come in, although there is no increase in the quantity of organic matter, there is a very considerable decrease in the quantity of free oxygen; that is to say, there is no doubt that the free oxygen has been maintaining the purity at that spot.

9979. Nearly all these rivers seem to me to be worse than the Thames?—Yes manifestly. There is a mistake I should like to point out, and that is the free oxygen of the river Wandle, which is put down in the table as ·01, whereas it ought to be ·1.

9980. That would bring it to about the same amount of oxygen as the river itself?—Yes it does.

9981. Is it right as regards the nitrogen and carbon?—Yes.

9982. Now, have you exhausted what you think would be useful information upon these tables?—Yes; but I should like to mention that I believe evidence has been given about some samples which have been taken at All Hallows pier. I will put in the analyses (*Table* 13, *Appendix AG.*), but I have nothing further to say myself about them.

9983. With regard to the river Ravensbourne, do you know whether any storm overflows were at work in the neighbourhood?—I do not know in the least; the samples were brought to me by a man of the name of Lewis.

9984. Now, with regard to the samples that were taken at All Hallows pier, what you are handing in are the results of samples of Thames water collected at All Hallows pier?—Yes.

9985. Which reach is that in?—It would be in the reach between Battersea and Deptford.

9986. What are you going to tell us about these?—I have not anything to say about them except that they are confirmatory of the other observations.

9987. What is your next?—The samples taken at the Northern Outfall at Barking; those were not taken by myself. I believe that there has been evidence given of the taking of those samples.

9988. Will you just state what this table (*No.* 5, *Appendix AG.*) shows?—I am bound to say this, that I think it shows very little. The fact is, these were samples taken at the Northern Outfall, Barking, but it is perfectly clear they are not pure sewage; here are samples with 187 grains of chlorine in them; it is quite clear a great deal of it is Thames water. There is one, No. 19, which contains 11, and there is one, No. 20, which

*Dr. C. M. Tidy, M.A., M.B.*

21 Feb. 1883.

contains 10, and in those cases the organic carbon is 4·8 and 3·9 respectively, but, as regards a great many of the other samples they are not sewage at all.

9989. They are a mixture of Thames water, sewage, and sea water?—They are simply mixtures of sea water with river water and sewage. I would say that some of these samples had a very strong sewage odour when they were furnished, whilst others after being kept a short time became very offensive. The quantity of free oxygen in these samples is worth noticing, and I am rather disposed to think if you had perfectly pure sewage you would find hardly any free oxygen at all, or only a very small quantity. It is manifest that these samples were mixed with sea water, and therefore, except that they have been referred to in the course of this inquiry, I should not have put them in. Now there are some samples which have been spoken of as having been taken at Crossness. (*Table No.* 6 *was handed in.*) These have been mentioned as having been sent to me, therefore I put in the analyses of them, but I venture to remark that the outfall of the sewage at Crossness is below the level of the river, and therefore all they could do in taking these samples was to lower the bottles into the river. That was the only method of taking the samples at all, and it is perfectly evident that what they got was a mixture of sewage and some sea water. The quantity of chlorine contained in the samples shows that it was hardly worth while taking them at all.

9990. The sewage you mentioned as containing 10 parts in 100,000?—Yes.

9991. Then that chlorine column shows that there is a large admixture of sea water?—Yes.

9992. And that title "sewage water" in your judgment is not correct?—If you mean by sewage water, water which contains some sewage, I accept it; it does not mean that it is true sewage; it means rather sewage and water, I presume.

9993. Have you any observations to make upon at table?—I think not, except that there are large quantities of ammonia in some of the samples. Now I will put in an analysis of a series of samples at Beckton. (*Handing in Table No.* 7.) The Beckton Gasworks have been referred to in this inquiry several times, and having occasion to go to Beckton periodically, I have made a point of taking a sample of the actual sewage itself upon the dates mentioned here in order to see to what extent this small thimbleful of materials which comes in at Beckton does pollute the river.

9994. It has been suggested that the sewage at Beckton does pollute the river?—Yes.

9995. (*Chairman.*) Where did you take the samples?—From the "catch" before it gets into the river; but here again it is manifest a considerable quantity of sea water has got into as it got into the Barking samples; and it is also noticeable that the amount of organic carbon and organic nitrogen is comparatively small. Though I do not dispute for a moment, I do not think there is a doubt about it, that the outfall does contain some sewage, because I know it does, nevertheless, the quantity of sewage is comparatively small. But there is another peculiarity to be noticed about these samples, and that is the quantity of ammonia present in them; that is very large. But we must remember that this is a gas-works, and although it is to the interest of the gas-works to preserve every particle of ammonia that they possibly can, and although as a matter of fact the plant at Beckton is admirably arranged for the purpose still there must be a little less, and that would account for the relatively large quantity contained in these samples. I know that at Beckton, and I am speaking now from what is within my knowledge, and within my own knowledge more than perhaps within the knowledge of most, exceedingly perfect arrangements exist for the purpose of retaining every drop of ammoniacal liquor, and they would not allow it to run to waste, still a slight leakage is incidental to all gas-works.

9996. They sell the residual liquor, do they not?—They convert it into the salts themselves; they do not sell it.

9997. Do you know what their process is of dealing with the sewage, is there anything to intercept the sewage?—No, it is only from a few houses. I think there are gaugings taken by Mr. Latham of the actual quantity.

9998. In the samples taken at Beckton do you find chlorine?—Yes.

9999. Does that indicate salt water?—Yes, there is some backward flow.

10,000. Here, as in the Crossness and Barking samples, does the suspended matter column show anything that is material?—At Crossness there is a considerable quantity. I think this is worth noticing, if I may be allowed to mention it, that in sample 17, for instance, at Barking, and again in sample 19, which looked to me more like samples of pure sewage than the rest on the ground that they contained very much less chlorine, the quantity of suspended matter is 35·4 and 31·1 respectively; I think that it is noticeable, that is to say, that in the samples in which I have no doubt we have got a purer sewage than in any other, the quantity of suspended matter is over 30 grains a gallon. That is also the case in No. 20, where, no doubt, from the quantity of chlorine it is more like true sewage, that there you have 29·2 grains of suspended matter per gallon. I do not wish to make more of it than is the fact, but I have no doubt it is so. Would you allow me at this point before you begin another part of the inquiry to put in some analyses about which I have nothing to say, but which will be dealt with in greater detail with some other analyses by Dr. Frankland afterwards, but it is necessary for me to prove them; I will only just put them in and nothing more.

10,001. (*Professor Williamson.*) There is one point you touched upon a little while ago upon which it would be interesting if you would give us some further information if you happen to possess it. I allude to the remark you made when you spoke of the diminution of the oxygen as you proceeded downwards in the river, and the consequent diminution of the influence which tended to destroy sewage. I understood you to say that in proportion as the oxygen diminishes in the manner you described, the quantity of salt which comes up in the sea water increases at the same time; and if I understood you rightly, the salt exercises, in your opinion, an action opposite to that which the oxygen exercises, that the salt which is present exercises rather a preserving power (I think the word "antiseptic" was used), which tends to preserve the organic matter as such, and to retard if not to diminish its decomposition. Now is that the result of definite well known facts, or is it the opinion you have formed from general probabilities, because of course you are aware the sea water brings not only salts but sulphates, and if those sulphates undergo decomposition under conditions which are not uncommon, surphuretted hydrogen is evolved?—It would be evolved by the decomposition no doubt, but with respect to the question of the salt I am afraid I have no facts to give you, my remark was of this kind, or at least I wished it to be, that in pouring sewage into running water (a question upon which I have often given evidence before) I had not the element of 300 or 400 grains of common salt to contend with, and knowing that it possesses a certain preservative power I was not able to say what was the preservative power it might exercise upon the organic matter. I have no experience to give you upon that question. Upon the question of the activity of certain proportions of oxygen, I think I am able to give you some facts. Would you allow me to say that the question of the reduction of the sulphates and the action of carbonic acid on the sulphide will be a matter upon which I shall speak afterwards. I have not lost sight of that action. As regards the chlorine I do not wish to suggest that I have any facts except *a priori* reasoning.

10,002. (*Mr. Lumley Smith.*) Are you now coming

to the result of your microscopic observations, or have you anything to suggest before you come to that?—I would prefer to go to that branch of the subject now.

10,003. You were going to say something I think before we passed on with regard to the sixth report of the Rivers Pollution Commission?—I will give you the reference to it. The composition of sea water was given by the Rivers Pollution Commission in their sixth report, and they closely confirm the analysis, in fact absolutely confirm the analysis which I have put in, on page 132 of the sixth report. If you will allow me I will read it. "In every case the organic matter "was highly nitrogenous, the proportion of nitrogen to "carbon varying from a ratio of 1 to 7·8 where we get "more nitrogen than carbon to 1·483, averaging a "ratio of nitrogen to carbon of 1 to 1·83." We have therefore an enormous concentration of the nitrogen on the carbon in some way or another, whether that is due to the fact that carbon is a body which is more easily oxidised than the nitrogen, so that we lose the carbon where we do not lose the nitrogen, or whatever it may be due to, there is the fact.

10,004. We are passing on now to the results of the microscopic observations, and perhaps, as a matter of personal convenience to me, the Commission will allow my learned friend Mr. Balfour Browne to examine you as to those results.

(*Chairman.*) Certainly.

Examined by Mr. Balfour Browne.

10,005. Have you examined the deposits in the various waters of the River Thames microscopically?—I have examined an enormous number of them, some thousands.

10,006. In doing so did you employ a staining fluid or did you look at the samples as they were?—As a matter of fact I adopted both ways.

10,007. (*Chairman.*) What system did you adopt?—What I did was this, in the case of a mud or of a deposit, I got it first of all into a conical glass vessel; if I could get a mud I took a considerable quantity of it, if I took a water I collected the whole of the deposit from a considerable quantity of water, mixed it up with distilled water and then allowed it to deposit.

10,008. (*Professor Villiamson.*) You did not filter it?—No; the object of that was that the heavier particles of mineral matter should go down first, and that I should in that way get upon the surface of the deposit, a layer of the lighter and flocculent organic matter. In all those cases if possible I took a duplicate sample to which I added a solution of hæmatoxylin for the purpose of staining. The real object of this was that I might bring out more distinctly any animal tissues that were there; and all the deposits and all the muds taken have been examined in that way. But before doing that, I set to work perhaps somewhat laboriously, to take the microscopic appearances of fæcal matter and the appearance presented by a water, to which I added a certain quantity of fæcal matter, mixed with other mineral matters, and in doing so I took advantage of an exceedingly elaborate investigation which has been recently made, and which I have perhaps taken as the basis of my work, by Professor Nothnagel.

10,009. Have those researches been published?—Yes.

10,010. And what was the substance of Professor Nothnagel's researches?—The substances that he pointed out as being of almost if not constant occurrence in fæcal matter, were first of all four things; muscular tissue, yellow elastic tissue fibres, shreds of fibrous substances such as fasciæ, and lastly, about which I shall have a good deal to say, spiral and free vegetable cells.

10,011. With regard to your investigations into the mud and river deposits, were they undertaken with the view of tracing these substances if possible?—Yes, those were the points to which I gave my attention in the first instance, but before proceeding to state the microscopic appearances, I venture to notice two things about these muds and deposits, the first is the absence, in the majority of cases, of any smell; that is to say, when the sewage mud is taken up from the bed of the river, it very often has no smell, but it will be invariably found that when it is kept in a warm place, as for example in a warm laboratory, the smell readily becomes very offensive. I presume the explanation of that is, that some of the more easily putrescible matters have undergone decomposition; then there is an interval, and then other matters become putrescible. It is quite clear that in observing the action of a quantity of sewage thrown into a very large tub, for instance, which I have done on a good many occasions, noting it day by day, there is a time when it smells very offensively; it then goes down and does not smell at all, then if you take a stick and rake it up you get the smell again, in fact you almost carry out what is done upon the river by the action of boats stirring the deposit up.

10,012. (*Mr. Balfour Browne.*) Have you ever taken up sewage mud from the bottom of the Thames when the temperature was very high?—I am certain to have done so, but I have no particular recollection of any one occasion.

10,013. Can you say whether that is or is not the odour you have detected in the laboratory?—I have smelt muds from the Thames which smell very badly, but some of them do not smell.

10,014. At any rate they develop a choicer bouquet when they have been kept in the laboratory?—Yes. Then another characteristic of a sewage deposit is a floculent and ill-defined surface; that is to say, if you take a large hand magnifying glass and look at this deposit in the conical glass, you will find that it has an ill-defined surface, it is a flocculent surface, whereas in a non-sewage deposit you will find you get a perfectly smooth well-defined surface, and the supernatant liquid is fairly clear into the bargain. What is very characteristic of the sewage deposit is the ill-defined surface and the absence of brightness of the supernatant water.

10,015. For this purpose you have compared sewage mud with non-sewage mud, have you not?—A very great number of times.

10,016. The inequality of surface is one thing that you have mentioned, but is it also the fact that the glass is dimmer in the one case than in the other?—Yes, taking a large conical glass, the dimness of the sides of the glass in the case of the sewage is a very marked feature of the observation.

10,017. The first series of observations were conducted with what I think you call undoubted sewage muds and deposits?—With undoubted sewage muds and deposits. I started with that in a great many cases, taking absolute sewage, also taking sewages that were artificially manufactured, and so on. I believe I did it in every way I possibly could.

10,018. Could you give us the dates over which those experiments ranged?—I may say these experiments were commenced for the last investigation in 1879; and since then I have been continuing them from time to time, and lately, since this case has come forward, I have done a great many more.

10,019. They are practically carried down to the present time?—They have been going on for three or four years. Now the first series of investigations were conducted for the detection of muscular and yellow elastic tissue, fibrous structures, vegetable cells, and other tissues. I took these because Professor Nothnagel had referred to them in his paper. Now as regards muscular tissue, fragments of muscle with distinct striation are constantly found in fæcal matter, but in sewage mud and deposits they are very rarely found indeed, and I think that depends upon the fact that striated muscle rapidly undergoes decomposition, and that amongst the earliest signs of that decomposition is loss of striation, and that where loss of striation occurs it is

*Dr. C. M. Tidy, M.A., M.B.*

21 Feb. 1883.

practically impossible to identify muscle in the mixed solution.

10,020. Does that decomposition of striated muscle take place more rapidly in water?—Yes, it does. In order to illustrate what I have done in this matter, I have had some chromo-lithographs taken to make it clear to the Commission, they only represent a few of the enormous number of drawings I have done to illustrate this case. I will first of all put in one plate and then another (*handing in some coloured representations*).

10,021. You have spoken of muscular tissue, is there anything upon these plates which shows what you have spoken of as striated muscle?—Yes, I have drawn one sample, it is only an ordinary piece of striated muscle which I found myself in a sample of water that was sent to me from Beckton, that appears in Plate A, Figure 2, and the small (a) in Figure 2. Now the next thing is yellow elastic tissue, that is shown on Figure 2 at D; and I would say that that again is a bit that I found in the sewage matter outside Beckton.

10,022. Before you go further, is that yellow elastic tissue a very important matter as characteristic of sewage?—It is exceedingly important and exceedingly characteristic. It is important because, unlike muscular tissue, these fibres resist putrefaction to a most extraordinary extent, they also resist the action of very strong chemical solvents into the bargain for a very long period; therefore the existence of that yellow elastic tissue is a very important thing. They not only resist putrefaction and the action of strong chemical solvents, but they are rendered unusually distinct by the decomposition of the tissue in which they take part, so that really when they are to be found, they become clearer from having passed through the alimentary canal, and clearer from the action of the water.

10,023. (*Chairman.*) How would you describe the small (d)?—As the yellow elastic tissue.

10,024. Will you state to what power they are magnified?—It is practically Ross' fifth that they were examined by, it is higher than a quarter of an inch. I think you might say they are magnified to 250 diameters. That being a very important thing, I would say these fibres are very frequently met with in muds, and very frequently met with in the deposits in question, near the outfalls, that I shall have more to say about.

10,025. (*Mr. Balfour Browne.*) You told us that the yellow elastic tissue resists the action of decomposition better than the striated muscle?—Yes.

10,026. Is it therefore much more commonly found in the muds than the straited muscle?—Yes; indeed I have given up practically the search for muscle now, because I know how readily it disappears and how accidental it is.

10,027. The next thing you looked for was the shreds of fibrous substances?—Yes, they are very often met with, particles for instance which probably make up the tendinous and fascial tissues are very often met with near the outfalls, and like the yellow elastic tissue, these particles also resist for a very long time decomposition.

10,028. Are you taking them in the order in which they resist decomposition?—No, I cannot say that I am, I am taking them as they come.

10,029. You have found these substances under the microscope?—Yes.

10,030. Have you figured them upon your diagram?—Yes, I have, but I will hand that in directly.

10,031. (*Chairman.*) The fourth division was the spiral and other vegetable cells and appendages?—Yes, as this is a matter of such very great importance I will try and make clear what I have to say about it. Of course the appearance of vegetable matter and particles of vegetable cuticle can be of no importance in determining the fæculent nature of any deposit, that is to say, vegetable matter will get in any way, and therefore that can be of no importance; but there is a very great peculiarity in the vegetable matter which has passed through the alimentary canal, that is the setting free of solitary vegetable cells or the setting free, more especially, of spiral vessels. On Plate 3 you will see the free spiral vessel has no investing membrance round it.

10,032. (*Professor Williamson.*) Were those samples obtained all in one field?—No, I am not giving them as actual samples, I am giving them to illustrate my evidence, they have been all put together in this case. Now the important part about these cells, and I am quite clear upon this point, therefore I speak definitely, the peculiarity I say is, that when the vegetable tissue passes through the alimentary canal the investing membrane will be dissolved, but the free spiral vessel is not acted upon by the fluids of the alimentary tract, that is to say, you may get the material containing this spiral (and I think the spiral is the most important infinitely) passed through the alimentary tract, everything dissolved off and the free spiral left alone. Now I have made a very large number of examinations of vegetable matter submitted to decomposition to see whether I could get a free spiral by simply decomposing vegetable matter, and I say I have never upon any occasion (and I have examined leaves of all ages and particles of cabbage which I have exposed to every form of action) seen the free spiral vessel produced as the result of ordinary decomposition.

10,033. Beyond the ordinary, the alimentary?—No, as the result of ordinary decay I ought to say, because there are two ways by which I could imitate these spirals; the first is by the action of boiling. If I take a quantity of vegetable which contains a large quantity of free spirals, like cabbage, I can by boiling separate the membrane and get the spiral; and the second is by the action of an artificial digestive fluid; that is to say, if I take a solution of pepsine and slightly acid pancreatine, I get a digestive fluid, by which I can separate the spiral, but I do not otherwise get perfect free spirals, so that free spirals are only practically produced by passing through the alimentary canal, and therefore the free spirals become exceedingly important as proving the existence of sewage. Now when vegetable tissue decomposes it generally decomposes *en masse*, the whole thing disappears. As regards that spiral vessel it seems to be, and certainly it is, very difficult to decompose it at all; when it is in the river it really remains a very long time unchanged. It is very different in that respect from muscular tissue, and whatever be its composition, about which I am unable to speak, all I can say is that it seems to be exceedingly persistent.

10,034. Is that in Figure 3 an unwound spiral?—It is an unwound spiral.

10,035. (*Chairman.*) Did I understand you to say that when pure vegetable matter is exposed to natural putrifaction, the spiral goes readily like the rest of the vegetable?—At any rate you cannot see it; I suppose it all decomposes *en masse*.

10,036. But when it is separated from the external membrane, either by passing through the alimentary canal or from the application of the ingredients you have mentioned, then the spiral membrane is not decomposed?—I do not say it is not decomposed, but it resists a considerable time, I do not say it resists longer under those conditions than in the other case.

10,037. That is what I wanted to know?—That I am unable to say, because the decomposition of leaves and other things is a matter of considerable time, and the whole might go together; I am unable to say that, but I only say that when you get these vessels let free they do last a considerable time, of course the decomposition of vegetable matter itself is a comparatively slow process.

10,038. (*Professor Williamson.*) If you could examine them step by step, perhaps you would find some of the tissues would last longer than others?—One would suppose so, but I have always found that the spiral tissue lasted very much longer than the others. I have examined leaves which have been decomposing two years old, but I have never yet seen a spiral left. I should like to say before I leave the spiral cells that

there is nothing in them that could be mistaken, they are as definite as possible, and they are as magnificently clear as anything you ever saw, there is no mere hazy outline to them.

10,039. (*Mr. Balfour Browne.*) There are also hairs of wheat and other cereals found in the sewage mud, are there not?—Yes, those cuticular hairs are very persistent, I had an idea at one time that they were broken bits of diatoms, but I have come to the conclusion that they are different things now.

10,040. Do you also find starch cells?—You occasionally find starch cells also.

10,041. I think some of them are shown upon your diagram?—I think not.

10,042. The hairs of wheat are shown upon your diagram?—Yes, they are, but I am afraid they do not represent the hairs very well there.

10,043. What is the next feature you have to mention which is characteristic of a sewage deposit?—You may look at many examples of deposit and not find the hairs or the spirals; but one of the most characteristic features of the sewage deposit is the yellow amorphous matter.

10,044. (*Chairman.*) When you speak of sewage deposit you mean fæcal deposit?—Yes, I am referring exclusively to the animal contamination.

10,045. (*Mr. Balfour Browne.*) You call that yellowish?—Yes, I call that yellowish, and it is distinctly yellow under the microscope. I think in this diagram it is a little dark, but at the same time it represents it fairly well. That deposit is important, because it undoubtedly is the most conspicuous feature of the sewage muds and deposits, and I have no doubt in my own mind, not a shadow of a doubt, that the origin of that material is animal.

10,046. In ordinary river muds there is a considerable amount of matter, what does that look like under the microscope, is it all like this, or is it angular?—It is totally different; I have shown at Figure X in the diagram the appearance of a mud-water deposit, which is not sewage, and it is perfectly definite, it has a number of sharp particles, you will find that there would be a sort of even layer of particles, of course it will vary a good deal, there would be a few pieces of vegetable structure, and you may get some diatoms and such like, but there is one thing which is very important to my mind, and that is its non-clustering appearance, you will find the whole field of the microscope is fairly and evenly covered, and when you look further you will see these particles (depending upon how successful you have been) evenly covering the entire field.

10,047. You say the particles have an angular shape?—Yes, the particles have an angular shape and are highly refracting.

10,048. Is that appearance at all seen in what you call the yellow amorphous matter?—It is totally different.

10,049. Have you seen anything like this yellow amorphous matter in any other matter?—Yes; I have examined it a great deal, it resembles portions of disintegrated muscle and matter from the dissecting room which have been in the water a long time. There is no doubt that by disintegration you get matter of this kind.

10,050. And have you ever tried the disintegration of such matters under water?—Yes, I have.

10,051. Is this appearance produced by decomposition in water more than in the air?—Yes; that deposit exactly resembles the molecular matter which is certain to result from the utter disintegration of animal tissues kept under water, and it at once distinguishes it from the disintegration of vegetable tissue. I think when one has seen it a good many times it would not be possible to mistake the disintegration of vegetable tissue for the disintegration of animal tissue under water.

10,052. What is the particular feature of vegetable decomposition?—A coarse sort of breaking up. It is a very difficult thing to express what takes place, it is in large pieces, and nothing like the simple amorphous granular material, distinguished by the breaking up of animal matter. I have, upon the whole, no doubt that the yellow amorphous matter is of animal origin.

10,053. (*Dr. Stevenson.*) Have you thought whether it might be attributable to any altered blood pigment?—I have wondered whether the yellowish material may be due to bile in any way.

10,054. (*Mr. Balfour Browne.*) Besides the granular yellow matter you describe are there other masses which appear?—May I first say that one has thought of all the various points that might be raised as to the yellow amorphous matter being indicative of animal rather than vegetable deposits; one might be tempted to say, for instance, in the case of vegetable cells, might they not break up and form a granular mass of this nature; I do not think they could. I can quite understand such a question as that being raised, but I entirely doubt whether in the breaking up of those cells we should get a body of that kind, still I can quite imagine the question being raised.

10,055. (*Professor Williamson.*) In the question you have raised under the head of disintegration, you assume that some putrefaction is occurring, you do not merely record a falling apart of solid constituents which were together?—No, I do not think that, so much as an actual change of the particle; for instance, keeping particles of muscle which I knew to be muscle, in water, I do not think you notice disintegration of the muscle so much as the loss of the striation of the muscle, there is disintegration really, but still it is a very minor form of disintegration. But when you lose that striation entirely, then it is impossible to say it is muscle.

10,056. Do not you find living organisms present while decomposition is going on?—Yes, undoubtedly, but I am sorry to say I cannot make very much of them.

10,057. You have not been able to examine them?—I have examined them, and I have examined into the diatom; in nearly all cases of sewage mud you will find shells of diatoms, and in some of them you will find the diatoms in active motion; but they are certainly not so frequent in mud which is not sewage. However I have never been able to know how far I could connect diatoms with the sewage, and it is very difficult to say, (equally so I think) with respect to the animal life which is generated under those circumstances, I am afraid I have nothing to say upon that subject.

10,058. (*Mr. Balfour Browne.*) To follow up the question which was put to you by one of the honourable members of the Commission, you say you do find organisms the result of putrefactive changes?—Yes.

10,059. You cannot trace organisms when the putrefactive change takes place in the muscle of a different kind from those of vegetable putrefaction?—No, I cannot find that. In an infusion of hay, you get them developed, and in an infusion of decaying animal matter you get them developed, and I cannot tell the difference between them. It is very difficult to deal with the question of living organisms. But may I add with regard to the young vegetable cells, my own impression is that the cell loses its characteristic aspect the moment its cell wall breaks, and I do not think a breaking of the cell would produce this effect even in young vegetable cells.

10,060. The breaking of young vegetable cells will not account for this yellow amorphous matter?—No, it will not.

10,061. Now upon plate A, what have you to say?—Here I come to another thing, which is to my mind very important, and that is the appearance of certain yellow masses; the yellow masses are, I think, distinctly different from the yellow amorphous material, (*pointing to the plate*), they are nearly or always found in sewage deposit, and I think that they are undoubtedly animal.

10,062. Upon what ground do you think that they are undoubtedly animal?—First of all there is an entire absence of every kind of vegetable characteristic about

*Dr. C. M. Tidy, M.A., M.B.*

21 Feb. 1883.

them. Then secondly, they present the precise aspect of disintegrated animal tissue. I have seen them over and over again from particles I have examined which I knew to be animal; you will very often find in those minute lines, dotted lines, and I think it would be very hard to conceive that those dotted lines could come from vegetable matter.

10,063. Are the dotted lines the same thing as we saw in the striation?—No, I do not think that. Then thirdly, I think this more important than all; I have seen several pieces where you will find a piece of muscular tissue at one end converted into a yellow mass at the other. I have drawn one specimen of that; it was a very remarkable one. You will notice (*pointing to the diagram*), that actually at one end you have the muscular tissue and at the other end you have the yellow mass. I do not know whether that has been due to some particles being placed over that particle so as to prevent its decomposition at one point.

10,064. Where is that?—That is 2*c* at the bottom of the plate. As a matter of fact the specimen which I have drawn there, I found in the mud of the Thames off the sewer outfall at Barking, and there you get the actual transition from muscle to this peculiar condition. I once said it was an adipoceratous condition, but I can only say if you take the covering glass and press it, it is distinctly soft, you can press it out. I think distinctly it is an adipoceratous condition.

10,065. (*Mr. Bidder.*) I think I recollect that particular piece; he is an old friend of mine?—I have brought that forward before,

10,066. (*Mr. Balfour Browne.*) Now is there anything else besides what you have mentioned which shows that this is of undoubted animal origin?—Yes, I have found many pieces since in which I have no doubt the fasciæ and tendons have been converted into this yellow mass; so that not only do I think these yellow masses may arise from the change which the muscle would undergo, but at the same time tendon and fasciæ would undergo the same change. I will now, if the Commission will allow me, hand in another plate, plate B. (*handing in the same*). I will refer you to Figure 3.

10,067. In that figure the portion of tendon is found in the water?—Yes; there for instance is a beautiful piece of tendon in a water deposit taken at All Hallow's Pier. Now there its fascial character is distinctly marked, and it has undergone conversion into this peculiar yellow deposit. I have seen a number of pieces, not only of muscle but of various forms of animal deposit which have undergone this change.

10,068. You have already mentioned the diatoms. are they found often in samples of sewage mud?—Yes, I thought at one time that one would have been able to make something of diatoms, but I do not think one can.

10,069. Would you or not say that diatoms are indicative of sewage mud?—I think that where you get sewage you invariably find perfect fusiform diatoms. I thought a great deal more once of diatoms than I do now. I think, in the previous inquiry I made more of diatoms than I do now, but I do not think much of them; still I think they may have something to do with the question.

10,070. You put in both these plates, but I wanted to draw your attention to any observations you may have to make with regard to the appearance presented by the sewage mud or deposit?—There have been a good many things I have thought of in regard to this question, that is to say, I have put two muds together at the bottom of plate A, a sewage mud and a non-sewage mud. Of course one thing which has occurred to me has been this. It might be said animal contamination is in the river, supposing that is admitted might it not come from the decomposition of large quantities of bodies of animals, dogs, cats, rats, and so on, thrown into the river.

10,071. X and Z are the figures you are directing attention to now?—Yes.

10,072. Are those actual specimens?—Yes, they are actual specimens, and each group was drawn exactly as I saw it; there is no collection here in these groups. Table B also gives actual specimens. Now the thing which struck me was that if these things were derived from the decomposition of the bodies of animals, first of all, in my opinion, the decomposition would more or less occur *en masse*; but secondly it appears to me that we should have found the hairs of animals more frequently in the river. In the numberless deposits I have examined from the river, I never found a hair but once, and that was the hair of a mouse.

10,073. (*Chairman.*) Do you find no human hairs in the mud?—No, and I am bound to say it is a very astonishing thing, I cannot tell you what is the meaning of it, I never found any hair at all except as I say, in one case the hair of a mouse.

10,074. (*Colonel Ewart.*) I have heard that at Bedford they complained that their pumps were choked by hairs?—So I understand.

10,075. (*Dr. Stevenson.*) Does hair readily decompose?—No, it is very indestructible.

(*Mr. Bidder.*) But that hardly explained it, because a good deal of the sewage does not come from the pumps.

10,076. (*Mr. Balfour Browne.*) If this animal matter were to be traced to dead bodies decaying in the river, like dogs and cats, and so on, you would have expected to find hairs?—Certainly.

10,077. Is it to your mind indicative of the fact that this decaying matter is coming from the sewage that no hairs are found?—That is an inference that one may fairly draw; and I think there is another thing, that the tolerable uniformity in which the animal fragments are found in certain samples of the mud deposit can suggest nothing but an extensive and a somewhat constant source of supply of animal matter. I do not know whether I convey the meaning I wish. I mean that the constancy of the appearance along the river seems to suggest to me a constant supply of the material.

10,078. (*Dr. Stevenson.*) Do you never find cotton and woollen fibre, house flannel fibres, and so on?—I have found cotton fibre, undoubtedly; a good many things I could mention I have seen that I have not put down here; for instance, I have no doubt whatever in my own mind that I have found blood cells. Starch again is a very common thing, but I have not burdened my evidence with those points; certainly cotton fibres I have found very of ten, but the absence of hair I admit is to me a very astonishing thing.

10,079. Have you found in these deposits fragments of dead worms?—Yes, lots of them; that is another thing that is somewhat remarkable.

10,080. Could they be mistaken for anything else?—No, they could not be mistaken for the animal tissues I have been referring to.

10,081. What kind of worms were they?—It was difficult to say, but it was perfectly evident from their look that they were worms.

10,082. Would you first refer to those two specimens and point out the characteristic of the sewage mud and as compared with other mud?—Taking these two specimens (*pointing to the diagram*) for instance, I have not put in the spiral upon the Fgure Z, because I did not see it when I drew it, therefore I left it out; out in Figure X there are particles of vegetable fibre, also are particles of a highly refracting body, silica, no doubt, and there is that dotted appearance of small mineral particles about the field; but an absence of clustering; there is no yellow amorphous matter, it is a sort of even layer; the extent of evenness depending to a great extent upon how far you have worked your specimen down. Then may I say with respect to the other sample, the Figure Z, you have there what is seen practically in every case, and that is the yellow masses and the yellow amorphous matter; it contains the hairs of wheat and some little bits of

dirt; and there is this curiosity about the yellow amorphous material which is shown upon that drawing, that in some cases you get a shapeless outline, whilst in other cases you get definiteness of outline.

10,083. In one case the matter, whatever it is, is evenly distributed over the field and in the other cases it is clustered as in Figure Z?—Yes, I have not a single doubt about the appearance of the sewage, and of the non-sewage deposit. The fact is that you get these particles of sand under the microscope, and you see little bits of this yellow amorphous material clustering round them, and it becomes very distinctive.

10,084. Can you trace the distinct characteristics of sewage mud more in the specimens taken near the outfall, and do those diminish as you get away from the outfall?—Yes, those deposits in the river, for instance, change their character; they change their character principally, I think, from two causes; first as the sewage deposit goes down the river, the solid constituents by reason of their different specific gravities undergo a process of sorting, that is to say the lighter particles will be found at a very much farther distance from the outfalls than the heavier particles; for instance, you will find that the deposits in the muds in different parts of the Thames are exceedingly characteristic owing to the dropping out of certain things, and other things being retained.

10,085. Can you detect this process of sorting by means of the mud?—I should say yes, in a measure at any rate; that is to say, in a short distance the yellow fibrous material, drops out and goes into the mud, and you lose it in the further deposits. The two things which are the most persistent are spiral vessels and this yellow amorphous material. Then comes a time when the spiral vessels drop out, and you get yellow amorphous material as the last remnant of sewage in the deposit.

10,086. And that is what you would expect to find at the furthest distance from where the sewage is poured in?—Yes, by means of this processs of sorting according to the specific gravity of the different bodies. The next point is the decomposition which various bodies undergo. As a matter of fact you can almost divide the Thames by means of the character of the Thames deposits.

10,087. The most resisting of these bodies being those to be found at the greatest distance?—Yes.

(*Chairman.*) Not the most resisting but the lightest.

10,088. (*Mr. Balfour Browne.*) Both are to be considered, both the specific gravity by which you get your process of sorting, and this resisting power by which you detect the spiral cells?—Yes, it appears to me that when you get a considerable distance from the outfalls there are two things, you get the yellow amorphous deposit and the spiral cells, and the last thing of all is the dropping out of the spirals. It would appear that the spiral cells drop out before the yellow amorphous material disappears; so I should say the last signs of sewage would be the yellow amorphous material. Then comes a very important point, I take it that the appearance of these two bodies, that is to say, the yellow amorphous material and the spirals in conjunction, is very important for this reason: that the spiral matter is of vegetable origin, and indicates to my mind, although not absolutely, yet almost absolutely, that the material has passed through the alimentary tract, whilst the yellow amorphous material is of animal origin; and so you get a combination both of animal and vegetable origin indicative of sewage.

10,089. Have you anything further to say with regard to the appearance presented by non-sewage mud?—I think I have almost said all I wish to say upon the subject. I wish to point out that on Diagram B, figure 4, there is yellow amorphous material and some vegetable matter, which latter was purely accidental.

10,090. You have not told the Commission, though I think it is printed upon the plate, where all these specimens were taken?—I think it is printed on Plate B.

10,091. Figure 1 at London Bridge, 2 at Blackwall, All Hallows Pier, and Chelsea?—Yes.

10,092. You say these figures X and Z represent sewage and non-sewage mud, where were those taken?—As matter of fact the one was taken opposite the intake of the West Middlesex Water Company; I have not a note of where Fig. Z. was taken. There is nothing very remarkable about it, but still I can get it for you before the Commission meet next time.

10,093. Now I will ask you this: from the Outfall Sewer to Bugsby's Reach upon the river can you tell, the Commission what is the character of the mud there?—May I put in a table at this point (*handing in Table No. IX*). This is an analysis of mud, I have nothing more to say about the analysis of mud, except that they were samples of mud sent to me, and clearly they are from the River Thames at different points. Looking at them and considering the quantity of organic matter they contain, and the quantity of nitrogen they contain, and the quantity of phosphoric acid they contain, I have no doubt of their being of sewage origin; that is to say, that they contain sewage. I do not say how much sewage, but merely that they contain sewage.

10,094. (*Professor Williamson.*) At what temperature was the substance dried?—They were all dried to 230° Fahrenheit. I would say that all the water deposits and everything of that kind are dried at that temperature.

10,095. How is the total amount of organic matter ascertained?—That is ascertained simply by burning; the ratio of nitrogen to carbon is estimated directly. As far as chemistry is concerned, I have no doubt that these muds contain sewage without saying anything about the proportions.

10,096. Under the head of phosphoric acid, here are figures for a certain way down the column and then blanks; were there no determinations in that case made?—No, they all came out very much alike, and they involved considerable labour, so I did not think there was any object particularly to be gained by continuing to make them. If I had found variations I should have gone on with them.

10,097. (*Mr. Balfour Browne.*) Now, have you anything more to say about the mud Table?—I want to say, that although the microscopic evidence is in no sense absolutely quantitative (which it is not) it is in somewise relatively so. For instance, I will give an illustration of what I mean in the case of spiral vessels. I have found spiral vessels at Hammersmith rarely, but I have found them occasionally as far as Battersea. Now comes the point, that up to Deptford they are fairly frequent, I might also say very frequent, I have no particular number to give for these places, you must take them generally. It is very difficult to say anything more than that they are very frequent.

10,098. Now I will ask you, as we are going down the river, have you ever found them above Hammersmith? Have you ever found them at Teddington?—No, I have not found the spirals at Teddington.

10,099. You have found some up at Hammersmith, and you have found them more frequently at Battersea, and more frequently at Deptford?—The way in which I would convey my meaning is, that from London Bridge to Battersea they are "occasional," from Deptford to London Bridge, "fairly frequent," but up to Deptford "frequent." I will give you from my own notes the result of the examination of the suspended matter of water. Particles of muscle are found tolerably frequently up to Woolwich; occasionally, but seldom from Woolwich to Greenwich, and not above Greenwich, except a mere isolated particle, which may be found now and then in any part of the river. Sometimes you may find a particle which may come in from other places, because there is other sewage coming in.

10,100. (*Mr. Bidder.*) This is striated muscle that you are now referring to?—Yes; this is striated

*Dr. C. M. Tidy, M.A., M.B.*

21 Feb. 1883.

muscle; when the striation is lost, you cannot find it at all. Then with regard to yellow elastic tissue, it is fairly frequent up to Blackwall, it is occasionally found between Blackwall and Bermondsey, and a few isolated particles in other parts. Shreds of fasciæ are not seen frequently above Blackwall; occasionally particles are found as far as Battersea. I am afraid this does not convey much information except that I see a larger number at one place than another. Then with regard to free spiral vessels in vegetable cells, these I have found as far as Battersea, and even Hammersmith. Up to Deptford they are very frequent; from Deptford to London Bridge fairly frequent, and from London Bridge to Battersea occasional. Then with regard to yellow amorphous matter and yellow masses, this seems practically to be the last remains indicative of sewage. I have found them as far as Chiswick, and so far as amount, is concerned, I should be inclined to think that the quantity present gradually increases as you approach the sewer outfalls at Barking. If I were to put it as I should be disposed to put it, it would be thus; that there is certain amount of indication of sewage in the higher reaches. Then the quantity gradually increases. We have amorphous material to start with, then we have spirals, then we get particles of fasciæ and tendon and elastic tissue, and then we get particles of muscle further down, till we get to the sewage outfalls; and although I cannot give you definite facts in proof, that seems to suggest not only an animal origin, but to plant the origin of the whole at the spot where you find the greatest number of particles.

10,101. (*Professor Williamson.*) Do you find that the organic matter in the mud keeps pace with the number of those particles in the microscope?—No, it is difficult to say the relation of the total organic matter to the total mud.

10,102. Does it appear, from your determinations of the proportion of nitrogenous matter in the mud, that a conclusion of the same kind as you suggest from your observations with the microscope is borne out by quantitative measurements, or does it not?—Whether the quantitative determinations of nitrogenous matter increase as you get nearer to the outfalls, in the same way as the various particles increase. I should not like to answer the question off-hand.

10,103. In your tables you have a larger quantity of organic matter in some parts than in others?—I do not think the question of the quantity of organic matter in the mud conveys much; it is rather the kind of organic matter that is important. I should prefer to regard the relation of nitrogen to carbon as the more important element in determining the character of the mud.

10,104. (*Mr. Bidder.*) Would you be able to tell us where the sample was taken which is marked "off Erith" in your Table IX.?—The question shall be answered.

10,105. (*Mr. Balfour Browne.*) Some of the samples of mud in this table you took yourself?—Some of the samples I took myself, and some were brought to me.

10,106. And you put them forward for what they are worth?—Yes.

10,107. You have summed up the result of your microscopic investigation, and you say you trace this impurity to the sewage outfall?—I think so; I do not mean to say that some of these things may not have come from elsewhere. I do not wish to imply that even in the most distant way, because I know the sewage gets into the river elsewhere, and I presume some of these things may get in in this way, but we know that we find the sewage matter, and the yellow amorphous matter, and the free spirals in the higher reaches. We know the yellow amorphous matters gradually increase in quantity, we find the free spirals also gradually increase in number, and we further find that as we approach the outfalls, we have added to these, other constituents of sewage, such as shreds of fasciæ and elastic tissue. Then, again, lower down we get particles of muscle joining the ranks of the sewage constituents of the suspended matter. It appears to me that there can be very little reasonable doubt, at any rate it is fair to assume, that the outfalls at Barking and Crossness may convey certain of their sewage constituents up the river.

10,108. Now, do both your chemical and microscopic researches show that the upper reaches are to some extent fouled by the outfalls?—I have not a doubt in my own mind that the Thames in the higher reaches is being rendered impure by the outfalls of the Metropolitan Board of Works; you can put it to yourself; 400 tons of material every day being discharged into the river, how can it do otherwise. It cannot do otherwise than foul it.

Adjourned to Tuesday next at half past 12 o'clock.

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# TWENTY-FIFTH DAY.

## Tuesday, 27th February 1883.

PRESENT:

SIR P. BENSON MAXWELL, IN THE CHAIR.

COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANCOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary.*

Dr. CHARLES MEYMOTT TIDY, M.A., M.B., called again.

27 Feb. 1883.

(*Mr. Balfour Browne.*) There is one matter which Dr. Tidy ought to prove, and that is the question about the analysis of the water at Grays—at this instant he has not his figures before him; perhaps you would allow us to put that in afterwards.

(*Chairman.*) There is one matter I ought to refer to, and that is the effect of the sulphates in the water, which we thought ought not to be overlooked.

(*Witness.*) I would say that part of the smell is undoubtedly due to the reduction of sulphates, as a result of which sulphides are formed, the action of the carbonic acid on which sets free sulphuretted hydrogen. I wished to mention one other thing, and that was respecting the absence of hairs. I explained how I obtained the deposit, viz., by allowing it to stand in a glass, and then lowering a fine pipette and taking up a small quantity. I found, if hairs of any size were present, they would not come into the pipette at all, and therefore I got no hairs; and I have no doubt the explanation of that small hair of the mouse being found was that it was sticking upon end, or something of that kind, and was

therefore drawn into the pipette—probably that is the explanation of it.

10,109. (*Colonel Ewart.*) There is one question I should like to ask you—you spoke about the time of putrefaction of fœces, which you gave very generally; could you give the Commission anything definitely upon the notes as your opinion as to the normal time in which you may expect putrefaction to set in?—I cannot; it differs in different fœcal matter, and it differs so much according to the temperature of the day—in hot weather, for instance, the putrefaction would be so much more rapid.

10,110. What, should you say roughly, in hot weather, for instance, as to the time in which you would expect it to set in?—I will think that question over. I should not like to give an answer off-hand.

Cross-examined by Mr. BIDDER.

10,111. I think you and I were pretty well practised together upon a former occasion, and now perhaps we may be able to shorten the matter. I will ask you some questions at first with regard to the latter part of your evidence, that which related to the miscroscopical examination. I think I understood you to say frankly upon the last occasion that you do not pretend that that has any quantitative value?—Decidedly not; is is what is common to all microscopic work, that it is not quantitative.

10,112. I do not know whether you described your process so fully upon this occasion as you did upon the former inquiry—practically, you took about the size of a walnut of mud and stirred it up in a conical vessel, and then waited some four or five minutes?—No, I waited 24 hours in some cases.

10,113. By that time a certain amount of it had subsided?—Yes.

10,114. And upon the surface of that there was more or less a flocculent appearance?—Yes.

10,115. That you drew into the pipette?—Yes, I lowered the pipette on to the surface.

10,116. And, having done that, you examined it and obtained the results you described to the Commission?—Yes.

10,117. Whether that flocculent matter that you examined was five per cent. or one per cent., or less, of the total suspended matter, you have no means of ascertaining?—The microscopic examination gave me no information on the point.

10,118. You will quite understand I am not touching the chemical analysis. So far as that microscopic examination goes, in the examination you described upon the last occasion, where you found any traces of sewage, either recent or ancient, or more or less decomposed, whether that sewage was present in that mud or in the suspended matter in the proportion of one per cent or 10 per cent. or one-10th per cent., that examination gives no information whatever?—No.

10,119. Therefore I think, with one other question, I may almost pass away, without wasting much time over the microscopic examination; but I will ask you one thing, you described upon the last occasion how the striated muscular tissue is affected first, the spiral vessels being more permanent; and last of all, you say there remains nothing that you can regard as of sewage origin; but our old friend the yellow amorphous matter—you have no information there as to the time which is requisite to produce these successive changes?—No, I have none.

10,120. For instance, with regard to these observations, if we roughly say that the presence of striated matter indicates sewage of the most recent deposit, the spiral vessels more ancient, and the yellow amorphous matter still more ancient; whether that antiquity is a matter of hours, days, or months, the microscope gives you no information?—No, none at all.

10,121. I will only ask you one question in detail, and then I think you can pass entirely away from the microscope. I think you told us last Wednesday that the yellow amorphous matter you had traced up to Chiswick; I think that was your statement?—Yes, in the suspended matter.

10,122. I think, if you will recall your evidence upon the former occasion, the Mud Inquiry—you will correct me if I am wrong—upon that occasion you traced it up to Teddington?—That had to deal with the muds; what I am referring to here is the suspended matter in the water.

10,123. It will be interesting to make a note that in the mud upon a former occasion you traced the yellow amorphous matter all the way up to Teddington?—That is so, and that this time in the suspended matter I traced it up to Chiswick.

10,124. I will endeavour, I think, as far as I can, in passing over the other parts of your evidence, to follow the order in which you gave it; you put in a good many tables, and I think one of those which you put in first, and which has a certain importance as bearing upon the tables which have been put in by the engineers, founded on chlorine, was a table of analyses of sea water; it is No. 4 in the tables which have been put in by the witness; you there give analyses of sea water at different places?—Yes.

10,125. There is one sample, I suppose, that we may put aside, though it has an interest of its own, but not in relation to this case, and that is the Dead Sea?—Perhaps.

10,126. Now I will ask you this, have you confidence in the accuracy of these results?—Do you mean of these determinations of chlorine?

10,127. Yes?—I have to within one per cent. or I would say to within two per cent. I would say that the question of the determination of chlorine where there is a very large quantity present is admittedly a difficulty, but that, if special care be taken, I believe it can as a rule be brought up to within one per cent., and invariably up to within two per cent.; that is the way I should put it myself. I am quite ready to admit a slight error in those determinations.

10,128. I am not talking about one or two or five per cent. now, but one or two things catch my eye. The Mediterranean is represented as having a very high quantity of chlorine. I suppose we know the reason of that; that is, that the evaporation is very much greater than the introduction of fresh water?—Yes; it has also a very large quantity of solid matter.

10,129. Now at Southend you have a considerable admixture of river water?—Yes.

10,130. If your table is true, the water in the river at Southend at high water, take June 10th 1882, is more saturated with salt than in any known place in the world, except the Dead Sea?—You must not say, "any known place in the world"; you may say, "any places mentioned in the table."

10,131. I withdraw the term "any known place in the world." I will put it, "any place mentioned in the table"?—That was an extreme expression that you adopted.

10,132. I withdraw it freely. Now the sea at high water at Southend is more saturated than any place of all those you have selected in all parts of the world except the Dead Sea?—So it is.

10,133. Do you believe it?—Yes, I know it is correct.

10,134. Notwithstanding the large amount of fresh water admixed with it?—Yes, I know it is correct.

10,135. I wish now to draw your attention to this, that even at low water, when there is a far larger admixture of fresh water with it, it is far more salt than the Mid-Atlantic, and salter than any of the other places mentioned in the table, except the Mediterranean?—Yes, that is so.

10,136. Do you believe it?—Yes.

10,137. How do you account for it?—I cannot give the reason for it. I know it is the fact.

*Dr. C. M. Tidy, M.A., M.B.*

27 Feb. 1883.

10,138. Do you mean to say that the water at Southend at the period of low water is more briny than the water in the Mid-Atlantic, for instance, or the sea at Brighton, or the sea at Margate, and equal to the sea at Penzance?—I say what I know is a fact, that on June 10th 1882 the water at Southend at high water contained more salt than the sea of the Mid-Atlantic on the day when that sample was taken, viz., January the 28th 1882; that is what the table tells you, and nothing else.

10,139. But I did not select those places, you selected them yourself. Now I ask, is it credible that the water at Southend at low water should be salter than the sea in the middle of the Atlantic?—It is certainly credible; it is the fact.

The *Chairman* intimated that the credibility was a question for the Commission, the witness having stated that that was the fact.

10,140. (*Mr. Bidder.*) Now I will ask you this; apart from these analytical results, do you think or would you expect to find the water at Southend at low water salter than the Mid-Atlantic?—I am only discussing it from my own facts. I am perfectly certain that this is the fact and that upon the day in question it was so.

10,141. Will you just be kind enough to answer my question, putting that observation aside; would you expect to find the water at Southend at low water ten per cent. more salt than the Mid-Atlantic?—But there are so many things in nature that you would expect to find that you do not find. That is the simple fact, and I tell you the simple fact that the water at Southend at high water contained 1,558 grains on the day it was taken, and that upon January 28th it contained in Mid-Atlantic 1,261 grains.

10,142. You are not surprised at it?—I am not surprised at anything.

10,143. Do you give any explanation of it?—I do not profess to give any explanation of it. I tell you that it is the fact.

10,144. Was the analysis made by yourself?—Yes.

10,145. Just to come back to the high water at Southend. We have been told a good many times, you know, that the standard sea water contains 1,961 parts in 100,000; if you will be good enough to turn that 1,558 grains per gallon into parts to the 100,000, how many is it?—2,225.

10,146. So that it could only be produced by taking standard sea water, and evaporating it until it had lost a tenth part of its bulk?—I do not understand what you mean by "standard sea water." I never used the phrase.

10,147. It has been used by a good many gentlemen here; it is not my phrase?—I never used the phrase "standard sea water." I never said that standard sea water contains 1,961 grains.

10,148. I daresay you can tell me how much salt that represents, because that 1558 grains is merely chlorine. Take it in grains to the gallon. (*The witness made a calculation.*)?—It is about 2581.

10,149. So that, if our total of solid matter was right, that is almost the entire solid matter contained in it?—Very nearly. I do not think that is quite the fair way to put it, because I do not say that the chlorine is there as common salt. I never said so. You asked me how much salt that would amount to, but I did not say it was there as common salt.

10,150. Then the chlorine does not indicate common salt; it may be there free?—No, not at all; it may be there as chloride of magnesium.

10,151. (*Chairman.*) Can you tell me this; it was at high water that you took the sample which showed 1558 grains, was it not?—Yes.

10,152. It is perhaps rather a geographical than a chemical question, but would you expect to find in that sample very much fresh water, seeing that the tide flows in from the north?—No, I should not from that point of view.

10,153. (*Mr. Abernethy.*) You see it is a very large funnel-shaped mouth, and that the tide comes in from the North Sea; would you expect to find much fresh water?—No, I should not. As a matter of fact, I should expect to find very little.

10,154. (*Mr. Bidder.*) You would expect to find at high water, with the tide coming in from the North Sea, no fresh water at all?—No, I did not say that; I said I should expect to find very little.

10,155. Would you expect to find any, or would you not?—I would expect to find very little.

10,156. If that be so, what becomes of the tables the engineers have put in, and their assumption that the water which flows past Southend Pier at high water contains as much fresh water almost as the water that flows down?—I am not dealing with the engineers' tables.

10,157. All Mr. Mansergh's and all the other tables are based upon the assumption that the water in the reach above Southend had that amount of fresh water which is due to the difference between the sea water and the sewage water and the water at Teddington. For instance, upon the 30th November Mr. Mansergh gives the absolute high water, and he gives the sixth division below Crossness, which is from Southend to five miles up. He gives in Table M 3 c the total content of the river, and he informs us that this section contains 13,686,657,600 cubic feet, and in column 6 the percentage of that which is fresh water is given as 13·70; that is what his table is based upon. He assumes that that has come up from below?—I have not considered it from that point of view.

10,158. No doubt, but it is interesting to see how the two sets of observations clash?—That is a subject which the learned Counsel no doubt will deal with.

10,159. Then I will ask you this: if Mr. Mansergh is right that there is 13·70 per cent. of fresh water at high water at Southend, it can hardly be consistent with the water being as salt as the sea in the Mediterranean?—I should like to consider that question before answering it; I have not considered it, and therefore I cannot give the answer off-hand.

(*Mr. Lumley Smith.*) You are comparing different dates; that table is dated 29th January.

(*Mr. Bidder.*) But Mr. Mansergh is dealing with various dates, and upon every occasion he assumes a certain percentage of fresh water.

(*Chairman.*) 1785 is the amount of chlorine determined by analysis.

(*Dr. Stevenson.*) That is, parts per 100,000.

(*Mr. Balfour Browne.*) Dr. Tidy's figure upon the 100,000 parts works out at 2,225.

(*Witness.*) As a matter of fact, I have not compared these tables at all. I have started entirely upon my own experiments.

(*Mr. Bidder.*) Do not let me be supposed to suggest that, because upon the 30th of November this gentleman, Mr. Mansergh, estimates that there is 13·7 of fresh water, that is necessarily the percentage every day; it will vary with the amount of land-water coming down the river.

(*Chairman.*) Upon the 14th of September the chlorine found by analysis is 1931 in 100,000 parts.

(*Mr. Bidder.*) That is a long way short of 2225.

(*Chairman.*) I am only showing how far it varies—whilst upon the 30th of November there were only 1522 parts.

(*Witness.*) I should like to point out that upon October 16th at high water I found 1930 parts in 100,000, that is 1351 grains in the gallon.

10,160. (*Mr. Bidder.*) Your dates do not synchronise exactly with the engineers' dates?—No, they do not.

10,161. Now I want to go on to a matter of more immediate importance with reference to the question of pollution. I think I understood you to say the other day that you did not place any confidence in the amount of the oxygen required to oxidise organic matter as a test?—I said I had not used it in this analysis, owing to the presence of a very large quantity of chloride of magnesium in the water which un-

doubtedly interferes with the action of the permanganate on the water.

10,162. Other chemists have given some evidence, I think, to the effect that there is a way of applying that test notwithstanding?—I do not mean to say that there may not be, for I have worked at that question of the oxygen required to oxidise organic matter as much as most people, and I am perfectly prepared to meet the difficulties which occur.

10,163. Upon the albuminoid ammonia there is no reliance to be placed?—No.

10,164. And upon the proportion or ratio of the nitrogen to the organic matter, that you have dropped?—I do not quite understand your question, because I have stated it certainly over and over again in these tables.

10,165. I mean the proportion of nitrogen to organic matter, not nitrogen to carbon?—Seeing that it is impossible in the water to estimate the total organic matter, it is totally impossible to say what is the ratio of the nitrogen to the organic matter.

10,166. You have given that up?—I never gave it.

10,167. Did you not do so upon the last inquiry?—Pardon me, that had relation to analyses of mud, and not to analyses of water.

10,168. Up to that time you thought that the ratio of nitrogen to organic matter in the analyses of mud was a matter of much importance?—I first thought it was of importance.

10,169. And you afterwards thought it was of very little importance?—That was a question of mud, and this is a question of water.

10,170. You gave it up?—Yes, I did, in the mud, but not in the water.

10,171. Now, if I do not misinterpret your evidence, the main indications upon which you put reliance now are the oxygen in solution and the ratio of nitrogen to carbon?—No, those are not all; I have certainly said a good deal more than that.

10,172. Are those the principal ones?—It is difficult to say are principal ones.

10,173. I will put it interrogatively, as I have not gathered it apparently from your evidence; what do you rely upon as the principal trustworthy indications of pollution?—I will go through them.

10,174. Take that great Table No. 1, and point out, if you please, to the Commission, and to me which out of all the results which are recorded there are those upon which you mainly rely as indicating pollution?—First, on the total organic carbon present.

10,175. That is the most important, is it?—I am not putting it in that way, you can never regard an analysis and say, this thing is of the highest importance, and this is of the second importance.

10,176. Put it in your own way.

(*Chairman.*) I thought you made a statement upon this point before, and that I had a note of it?—I said the points upon which I specially relied were, firstly, the total organic carbon; secondly, the total organic nitrogen; thirdly, the ratio of the nitrogen to the carbon; fourthly, the free oxygen; and fifthly, the ammonia.

10,177. (*Mr. Bidder.*) I do not recollect that you put forward the total organic carbon or the total organic nitrogen by themselves, as being an indication of sewage pollution?—The quantity of organic matter.

10,178. As arrived at by the combustion process?—Yes, I think I told you the total matter; the organic nitrogen and carbon was an index of the quantity, and the ratio was an index of the kind; I stated that distinctly.

10,179. Your first is, total organic matter, as arrived at by C+N?—Yes.

10,180. Secondly, the ratio of nitrogen to carbon as indicating the kind of pollution, animal or vegetable?—Yes.

(*Chairman.*) If you refer to question 9843, I think that is about the part of the evidence where the witness stated what his points were.

10,181. (*Mr. Bidder.*) Pardon me for a minute if I take them in a somewhat different order from what you put them in?—I think it is immaterial myself, so I shall not quarrel with that.

10,182. I will go first to the question of the free oxygen; you told us, I think, that you took as your standard, to compare with these polluted or suspected examples, normal river water?—Normal Thames water.

10,183. The normal Thames water should contain two cubic inches of free oxygen to the gallon?—I did not say it should, I said it did.

10,184. Is it the fact that your own observations show you, and satisfy you, that that is only true in the winter, and that in the summer the proportion is a little more than half that?—It is so, you are perfectly correct there, I said as distinctly as I could that the quantity of free oxygen varied with the season, or, in other words, with the temperature.

10,185. Forgive me for reminding you that the only figure you mentioned to the Commission as the standard was two cubic inches to the gallon.

10,186. (*Chairman.*) Question No. 9848 refers to that point?—I should be very happy to go through a huge body of results if you wish it. I think I may give you the facts upon that subject. The question is, does the free oxygen in the river vary; to that I say, it does, and I am now going to deal with the facts bearing upon the question.

(*Mr. Bidder.*) That is not what I asked.

(*Chairman.*) You did suggest that he mentioned a figure which it might be imagined was particularly favourable to the view he took of this case, whereas he had suppressed other figures.

(*Witness.*) That was my impression.

(*Chairman.*) I think that is the view you took of the question, but it will be time for you to do that when your counsel re-examines you.

10,187. (*Mr. Bidder.*) I will give you an opportunity of doing it before I pass from the subject. I will promise that you shall have that opportunity. I never take an unfair advantage of a witness. Now, is not this first what you did say, that the Thames river water contains about two cubic inches, which varies, however, with pressure and temperature; that is, at 9848?—Yes, and I said so. I made the statement that normal Thames water contains about two cubic inches of free oxygen per gallon. That statement was made on the results of between 4,000 and 5,000 analyses which have been made during the past two years and a half. It is only during that time that we have had a method suggested of correctly estimating the free oxygen in water; that is to say, in such a way that we can use it. Practically, we had methods of doing it before, and although upon previous occasions, in a report which I published, I gave some analyses of the gases dissolved in Thames water, it was on a comparatively few experiments. Since then, as I say, I have made an enormous number of experiments, of which I have the results here.

(*Chairman.*) I think it will be time enough afterwards if we should require them.

10,187*a*. (*Mr. Bidder.*) I do not wish there to be the slightest ground for saying that I interrupt you, but if every question is made the subject of a long essay, your evidence will take a very long time. At question 9848 I have exactly what you did say. "It is some-
" times as low as $1\frac{9}{10}$ths of a cubic inch per gallon,
" but it may be said generally that the water of the
" Thames contains two cubic inches of free oxygen
" per gallon. It is sometimes 2·2, it sometimes
" goes down to 1·9 and even to 1·8 of free oxygen
" per gallon"?—Yes.

10,188. Now I will draw attention to what you have said in a report or pamphlet published by yourself very recently, and laid before the Chemical Society 1880—that is not quite before the flood, you know. You there say, "The only point worth remarking
" is that the oxygen in solution during the winter
" months was found to be very nearly double the
" amount found in solution during the summer months,
" or exactly 2·19 cubic inches in the winter, against
" 1·19 cubic inches in the summer"?—I think it is

*Dr. C. M. Tidy, M.A., M.B.*

27 Feb. 1883.

right to say I have explained that it is only within a very short time that we have had a method that Schutzenberger suggested, which is the process by which we do it now.

10,189. Would you say that in 1880 chemical science was in such a crude condition that you did not know how to estimate within 50 per cent. the amount of free oxygen in water?—No, but I would say that we used not at that time to estimate the amount of free oxygen in water, except incidentally.

10,190. Had you not at that time, as this table shows, in 17 analyses during the summer months, from May to October, obtained the result of 1·19 cubic inches, while in 10 analyses, made in the winter months, you got a result of 2·19 inches?—Yes, I do not dispute that at all.

10,191. Now, whatever may be the progress of science, in 1880 you were able to find two cubic inches when it was there, and your analyses up to that time show you the fact that, whereas you could find two cubic inches and upwards in the winter, in the summer you could only find one?—I can only say I got this result at that time, and that, by an improved process of observation (which is a very fair thing to say) on a very large number of experiments, I got a very much larger quantity.

10,192. But is it "a fair thing to say"; surely the process of 1880 was good enough to compare the results of one time of year against another, and the same process you tell us gave double the result in winter that it did in the summer?—I am bound to say I do not believe the oxygen did go down to 1·1; I do not believe it.

10,193. Then you do mean to say now that you place no reliance upon the process by which you found two cubic inches in the winter and only one inch in the summer?—I have altered my opinion subsequently.

10,194. (*Chairman.*) I understand you to say you have made these two sets of experiments by two different processes?—Yes.

10,195. Which do you consider the more reliable?—The present one.

10,196. If the former statements differ from those results you obtain now, do you place any reliance upon them?—No, I do not. I prefer to adopt the present process.

10,197. (*Mr. Bidder.*) You are satisfied that the results you obtained in 1880 are worthless?—No, not at all.

10,198. (*Dr. Stevenson.*) Would the older process furnish you with comparative results; would the summer and winter results compare with each other?—Yes. I may say that every fourteenth (I used to make every tenth), but every fourteenth, experiment is now estimated actually. I quite admit that the Schutzenberger process does give a slight error, and I know the error that it gives, but it is not of any moment.

10,199. But does the old mode you spoke of give comparative results, or does it give fallacious results?—There is no secret in the way these former analyses were made; the water was taken and boiled, and, the oxygen being collected in a Cooper's tube, a piece of potassic hydrate was put in to absorb the carbonic acid, and some pyrogallic acid added, by which the oxygen was then absorbed.

10,200. But do you think that the results of the analyses in summer and winter could compare with one another?—I should be sorry to say exactly, but I should think they ought.

10,201. (*Dr. de Chaumont.*) You mentioned that in every fourteenth experiment the oxygen was determined absolutely; will you tell the Commission how that was done?—It was done by boiling, but I did it by means of a pump.

10,202. Did you determine it by way of the pyrogallic acid?—I now measure it in one of Dr. Frankland's gas apparatuses, which I did not use before. I used in the old experiments an ordinary bent tube—a Cooper's tube—it is only within the last two years that I have estimated the free oxygen in every water.

10,203. But it is older than that?—The process is.

10,204. (*Mr. Bidder.*) It is the fact, is it not, that sea water contains much less free oxygen than river water?—No, that is not so, it is a little less undoubtedly, but not much.

10,205. You said, I think, that it varied from 1·7 to 2·1?—Yes, but I could only give you the observations made upon the water at Brighton, as that is the only opportunity I have had to examine it in any detail. I stated that over 50 determinations were made of the water at Brighton, and it varied from 1·7 to 2·1; practically it was two cubic inches.

10,206. By-the-bye, before I go on to another point, of course, if there were any foundation at all for, or any correctness in, this statement you made in the pamphlet, that, in the summer months, the quantity of free oxygen falls to something very much below the two cubic inches, it would not be fair to draw the deductions which you did from the percentage of oxygen in the Tables here?—Manifestly not, but I should like to say that all the deductions have been drawn upon experiments made in the same way.

10,207. Do I understand you to say that the more recent and improved method of the last year or two, entirely or substantially, negatives the result that was then stated, that in summer the oxygen in solution falls to very nearly half of what it is in winter?—I should not like to say that, I wish to say that by the method adopted now, I never get at anything like 1·1 in Thames water above Teddington.

10,208. Would you kindly tell us with your improved methods and increased science what you do get it at?—I will take it for last year. I will take January 1882.

10,209. Could you give us without giving the detail, the average result of a large number of summer, and the average result of a large number of winter observations?—Will you allow me to read you seven numbers which are the averages of a large number of observations.

10,210. You may read anything you like?—During the month of January we got 2·22, 2·08, 2·15, 2·15, 2·20, 2·16, and 2·20. Let me say that these results Dr. Odling is responsible for as well as myself.

10,211. Now take July—let us go to a corresponding summer month?—In the month of July I have the following figures 1·80, 1·66, 1·81, 1·78, 1·78, 1·81, and 1·76.

10,212. That sounds like an average of about 1·75?—Yes, 1·75 or 1·80. Now the next month, 1·79, 1·73, 1·80, and 1·81.

10,213. That is again very nearly 1·75?—Then when we get to September it goes up again, 1·90 and 1·81.

10,214. So that for the purpose of comparison, at any rate the 2 cubic inches must be brought down to 1·75?—No, say 1·8. If you take the average of the year it comes to about two cubic inches per gallon.

10,215. I entirely decline to take the average of the year when discussing summer samples; these samples in your Table 1 are taken in the months of June and July?—I think you are quite right there.

10,216. So it comes 1·75 as the result of your more recent observations. In fact your table itself shows upon the face of it (I am still upon the first table) that that is about the best result, taking the average of them, that you get up at the head of the river; Teddington, and about there some are a little more and some are a little less?—Yes, I think that is so.

10,217. Now I go to a point I touched upon prematurely. Do you agree with me, that if it were the fact that oxygen in solution in sea water were much less than in river water, as you go down the river and get an admixture of sea water, you ought to get a continual diminution of the amount of free oxygen?—Manifestly, if the quantity of oxygen in sea water was less than in river water.

10,218. Practically, you say it is not?—I say that my own observations have led me to say it is not.

10,219. Is that quite so; let me draw your attention

to your own Table 10. The water you told us a little time ago at Southend Pier was practically sea water?—Yes.

10,220. Now I will draw your attention to Table 10, and that shows that at Southend Pier at high water, when we are supposed to have practically pure sea water, according to you?—I did not say so.

(*Chairman.*) It was I that suggested that.

10,221. (*Mr. Bidder.*) You see the fact that your own analysis finds at Southend Pier at high water 1·39 at the bottom and 1·31 at the surface?—Yes.

10,222. Now be that mixed, or be it pure sea water it is the water that feeds the Thames above Southend Pier, is it not?—Yes.

10,223. And as that has only two-thirds of the quantity of fresh water that you say is pouring in at Teddington, you ought to expect a constant diminution of the quantity of free oxygen as you go down the river?—Yes, to that extent, no doubt.

10,224. But it is a substantial extent, because it is only two-thirds of it?—It is perfectly manifest that upon that date there was less free oxygen at Southend than at Teddington.

10,225. But it is your own analysis; it is not mine.

(*Chairman.*) What is the amount of free oxygen as a general rule in salt water, you said it was a little less; how much less is it?—It varies somewhat; 50 determinations of the oxygen were made of the water at the West Pier at Brighton; that is really the only basis that I had to go upon, and it varied from 1·7 up to 2·1 cubic inches. There were one or two numbers, such as 1·69; but, omitting those which I think I have the right to do for certain reasons, I think you might take it from 1·75 to 2·1.

10,226. Are those the averages?—No; those are the extremes; but it is right to say that that was entirely upon the one water which I had the opportunity of examining.

10,227. (*Mr. Bidder.*) For our purpose in discussing the estuary of the Thames above Southend, and its condition, why is not your observation at Southend Pier at least as reliable a one as the one taken at the end of the West Pier at Brighton?—I did not say it was not.

10,228. It is more valuable, is it not, for this purpose?—I am not discussing that.

10,229. This element of free oxygen is also liable to very violent fluctuations, is it not, without apparent cause. Of course everything has a cause if one only knew it; now take your Table No. 5 at Chiswick, I see your free oxygen upon the days you took it, the 16th and 17th, dropped at 11 at night from about 1·7 and 1·6 to 1·2, can you account for that?—It is very difficult to explain some of these things. It is possible that at that time the action of vegetation may be less.

10,230. Before we come to the table in which you charge the diminution of oxygen entirely to us it is a fact, is it not, that at one place, viz., Chiswick, far or remote at any rate from our influence, you have fluctuations to the extent of 33 per cent. in the amount of oxygen within a few hours?—It is perfectly true I did get these fluctuations, and it is right to put these fluctuations in, you must take them as they are.

10,231. Again I go to another part of the river, Table No. 17. Now here we have a very different part of the river, and in the samples of the water at Erith I find there are very astonishing and rapid fluctuations?—There are very remarkable variations.

10,232. Now what you would expect at Erith, (Erith being below the outfall a few miles) would be a diminution of the amount of oxygen at low water and an increase of oxygen at high water?—Yes.

10,233. Will you tell me shortly, if I am not right in saying that you very often find that exactly the opposite thing happens?—Yes, I am bound to say that Erith is one of those places which has somewhat surprised me over and over again. I think it right to say I have many results from the water at Erith which are very incomprehensible. I quite admit all these great variations.

10,234. Now I will ask you this:—does not the admitted liability to such gigantic variations which, as you properly say, are quite incomprehensible, shake your reliance upon the influences and deductions from the Table?—Yes, it would, if the inferences were drawn from a single place or determination, but in recording the analyses you cannot take one single thing and draw deductions, you must take several things.

10,235. You have not marked high water upon that paper, but I suppose one may pretty fairly infer from the amount of total solids, which was high water and which was low?—Yes.

10,236. Take October the 30th, at 10 a.m. and four p.m. I am not wrong, am I, in assuming that at 10 a.m. when you found 70 grains of solid matter in the water, it was low water?—Yes.

10,237. And that four p.m. when you found 273·30 grains it was high water?—Yes.

10,238. At 10 a.m. there was 1,848, a very fine supply of free oxygen and that that dropped down to 1·518 at high water?—Yes.

10,239. According to your views that is quite the opposite of what ought to occur?—Yes, I quite admit that it is not what you would expect.

10,240. But I am putting it to you, is it not diametrically opposite to what you would expect?—I am sorry to say you very often find results diametrically opposite to what you would expect.

10,241. Then I will pass from that for a moment; now I will ask you another question about the oxygen in solution. I am coming to the results in Table No. 1. I assume you did not take the samples yourself?—I took every sample in the table myself, except two; I think I have mentioned that circumstance before.

10,242. The process, as I understand or the method of taking samples and subsequent proceedings were that you filled a bottle with the water, you stoppered it at once, and took it home and examined it within 24 hours?—Yes, for the free oxygen.

10,243. I suppose, if your hypothesis was right, that in certain cases the water which you took was polluted water containing oxidisable sewage matter, that in the 24 hours it was standing, that oxidisable sewage matter necessarily took up a certain quantity of the free oxygen?—Yes, it may have done so, but I think I explained that, as far as my experience went, if you filled a bottle quite full, and then put the stopper in, so as to prevent any shaking about of the water you would reduce the oxidation in the bottle to a minimum. I am quite ready to admit there may be an error, but it is a very small error, if it is analysed shortly after the sample is taken.

10,244. Either the water contains no putrefiable matter, or if it does contain oxidisable and polluted matter, it is reasonable to expect that some of the oxygen will, in the 24 hours, have been absorbed?—Yes.

10.245. Have you any experiments which tell you the time within which the action will take place?—I could give you some results, and I will tell you how I have arrived at them. I have done it first by estimating the quantity of free oxygen in the water taken at the moment, and then in the water after 24 hours of the same samples, and I have found the results very nearly identical. I am going to give you one or two cases in point inasmuch as your question has raised a very very fair question. First, as regards a water containing a large quantity of vegetable matter, a very great number of those observation were made upon the water of the Shannon, where I had an opportunity of estimating the free oxygen in the water as I looked it out of the river directly, and then from samples of the same water after it had been out of the river some time; although I admit the quantity was a little less undoubtedly in the latter case, yet it was very slightly less, and not a point to make a difference of.

10,246. (*Professor Williamson.*) I wish to ask you whether that was water containing organic matter similar to that which is supposed to be in the Thames, or whether it was peaty matter?—I was trying to give

*Dr. C. M. Tidy, M.A., M.B.*

27 Feb. 1883.

an illustration of the two kinds of water; first, as to vegetable matter and then as to animal matter. Now the results of the second experiment also coincided with those upon the water of the River Shannon. There is a small cutting which receives a considerable quantity of sewage from a little town south of Lough Derg, called Killaloe. It is a small cutting from the main river. I had occasion to examine that very closely, and there was some sewage, organic matter, going into the river I cannot tell the quantity, but, at any rate, the oxygen there is reduced to a very small quantity. There again, being in a boat upon this river, I estimated the oxygen in this water very carefully on the spot, and then took a sample back and estimated it again. I admit again, that the quantity of the free oxygen was less in the subsequent examination, but it did not amount to any alteration in the first place of decimals.

10,247. (*Professor Williamson.*) Was that in the summer or winter, was it warm or cold weather?—That was last August.

10,248. It was in hot weather, then?—Yes. Now, although I admit there is a slight difference, it is not one which makes any difference in the first place of decimals, but if you do not fill the bottle, if you leave a part empty at the top, and shake it about and take it home, then it does make a difference.

10,249. (*Mr. Bidder.*) Then there is another cause, there is oxygen in the air of the bottle?—You get the mechanical action, I think.

10,250. Now I am going to ask you what may appear to be a stupid question. Supposing you put into a bottle of water, say of Thames water, containing free oxygen, five per cent. of fresh sewage, and cork up that bottle, why should the sewage in the water oxidise more slowly so long as there is oxygen to take up, than if it were in the river itself two or three feet under the surface?—There are a good many difficulties in that question. It has been under discussion a good many times. I have always held (though it is a subject upon which Dr. Frankland and myself have not absolutely agreed) that it is not possible in the laboratory by shaking up water in a bottle to imitate what is going on in nature; in the first place, there is no vegetation in the bottle and you lose the chance of setting free oxygen in a somewhat hyper-active condition.

10,251. Have you ever tried any experiments at Barking with the Thames water with the London sewage in it, with the view of ascertaining what is the amount of free oxygen in the water?—Yes, many.

10,252. (*Dr. Stevenson.*) You spoke of a particular water in a cutting of the Shannon which included animal matter, what initial proportion of oxygen was there when you took your samples?—I cannot give it you at the moment.

10,253. It was very small, was it not?—It was very small, but it will be one of those points to which I shall have to refer, as well as the point upon which the learned Commissioner asked me a question about the activity of oxygen in different quantities.

10,254. (*Mr. Bidder.*) With respect to the Shannon observations, I do not quite understand how you were able to estimate at the time in the boat the quantity of oxygen in the water?—I had all the apparatus. I have a box which holds everything necessary for the estimation of the free oxygen, and I make a point of always taking it with me when I am engaged upon this kind of observation.

10,255. Is this a recent observation?—Yes, it was taken last year.

10,256. Were you all agreed that fresh sewage matter does oxidise, and in oxidising necessarily does take up oxygen from the water of the river?—There can be no doubt about that.

10,257. There can be no doubt that you must find lower down in the water of the river in which the sewage is placed a certain diminution in the quantity of free oxygen?—Exactly.

10,258. The very fact of finding a diminution in the quantity of free oxygen is a sure indication that the river has been doing its work in burning up the sewage?—I think so. If you find a small quantity at one spot and lower down you find more oxygen, it either means that water has come in containing a very large quantity and so has raised the total, or it may be that the river has done its work and is recovering itself by becoming a little more oxygenated; you must not take either view too precisely.

10,259. But taking a case like this where the river you say above Barking contains a considerably larger quantity of oxygen, and by the time it has flowed down to Erith, and has got the sewage in it, there is a considerable falling off in the oxygen, that is *pro tanto* an indication that the river has been doing its work, that is to say, burning up the sewage?—Yes.

10,260. Subject to the other observations I made some time ago, that there is a certain diminution due to the admixture of sea water?—Yes, that is what I said just now.

10,261. But I make reference here to the very rapid diminution which takes place in the river where the proportion of diminution due to the admixture of sea water is not great?—Yes, that is so.

10,262. Now when you come down to ·6, and ·5 of an inch to a gallon at Crossness, that throws some light, does it not, upon another element upon which the river-side gentlemen have been very profuse in their eloquence, namely, the absence of fish in the water in that part?—I do not know the quantity of oxygen which is necessary to maintain fish in water.

10,263. When you find that the quantity of oxygen has been reduced to a third of the normal, it may be sufficient to indicate that it is insufficient to support the life of fish?—Yes, but you are regarding the free oxygen as if that were the only constituent of the analysis.

10,264. Not at all; we have had 50 gentlemen describing the great paucity of fish in that part of the river, and Lord Bramwell thought I was putting a paradox when I said that that did not necessarily suggest there was any poison in that part of the river?—Quite admitting that the diminution of oxygen may materially influence fish-life, although I do not know how much oxygen is necessary to do so, yet, quite admitting it may be so, we have set free by the reduction of the sulphates of the water and the action of carbonic acid on those suphides so formed, a gas which is undoubtedly infinitely more deleterious to animal life than the mere reduction of the free oxygen.

10,265. If a gentleman were found in a hermetically sealed room lying dead and you found there was no oxygen in the air, you would not go about to look for prussic acid, would you?—My own experience of forensic cases leads me to say I should; I never believe that the apparent cause is the real cause.

(*Chairman.*) If you put in something which takes all the oxygen out of the water, and makes it unfit for the maintenance of fish life, I suppose the unfitness of the water for fish life would be due to that which you had put in, which had consumed the oxygen.

(*Mr. Bidder.*) Undoubtedly, but I am suggesting at once that the water is inimical to fish life because the sewage has taken away the oxygen; but at the same time you must not draw the inference that there is anything actively poisonous in the water.

(*Chairman.*) You take away an element which is necessary to life.

(*Mr. Bidder.*) I do not admit that that is the sole cause.

(*Witness.*) It is the setting free of the sulphuretted hydrogen from the reduced sulphates of the sea water, which sets free a noxious gas which is itself a very active poison; it is not necessarily the taking away of something which is necessary to life but it is putting in what is actively inimical.

10,266. Have you any observations as to the poisonous effects of the actual sulphuretted hydrogen?—No, I have not here.

10,267. You have yourself told me that you were very much struck, in examining the muds in this part

of the river, with the absence of smell?—Very often that is so, but at the same time I do not say I have not smelt a smell over and over again.

10,268. Now let us go to another point; the ratio of the nitrogen to the carbon, as I understand, and you will correct me if I am wrong, your views are these, that the ratio of nitrogen to carbon is an indicator of the source of the organic matter and that the rise in the ratio of nitrogen to carbon indicates animal rather than vegetable origin?—It is the larger quantity of nitrogen in the organic matter which is so indicative.

10,269. Is that a fair inference in things like this, where you are dealing with a tidal estuary; have you not already told us that the sea water itself contains a very high ratio indeed of nitrogen to carbon?—Yes, I have admitted that.

10,270. It is 1 to 1·5?—Yes, quite so.

10,271. And therefore, as in the case of the free oxygen, it necessarily follows that if there were no sewage and nothing of that kind polluting the river, inasmuch as, as you go down the river you increase the proportion of sea water, you ought to find the ratio of nitrogen to carbon rise?—Yes, I have said so.

10,272. Is it not the case that the admixture of sea water, having regard to the high ratio you have spoken of, is quite sufficient of itself without anything else to account for the rise which you have in this table of the ration of nitrogen to carbon?—I have not regarded it from that point of view.

10,273. I ask you is it not the case?—I cannot answer that question.

10,274. You find a certain rise in the ratio of nitrogen to carbon; do you account for it by assuming that it is produced by the admixture of an ingredient, that is to say sewage, in which if I recollect rightly you say the nitrogen to carbon is in the proportion of 1 to 1·6?—But I never accounted for the rise in the ratio of nitrogen to carbon entirely by the addition of sewage.

10,275. Then I will withdraw that. I think I understand you to say that the rise of the ratio of the nitrogen to carbon indicates to your mind organic matter of animal origin?—Yes, I will accept that. You are now putting it as an abstract point. I admit it.

10,276. That is its value in discussing these tables of yours?—Manifestly.

10,277. And that is what you rely upon?—No, I do not rely upon any one thing specially.

10,277*a*. Do I understand you to suggest to the Commission that the progressive rise in the ratio of nitrogen to carbon, which you find as you go down the river is (among other things if you prefer) an indication of an increasing pollution of animal origin?—Yes, one of the things suggestive of it.

10,278. Is it not equally accounted for by the presence of sea water?—Yes.

10,279. (*Mr. Lumley Smith.*) You will find that in the answer to question 9,892?—I explained that very fully upon the last occasion.

(*Chairman.*) The question was "then the ratio of nitrogen to carbon is as 1 to 1·77," and the answer was, "Yes. (*Q.*) That is very different from what you "find in the pure water? (*A.*) It is very different "(*Q.*) It is more like what you get in sea water. (*A.*) "Yes, it is more like that." Is that the passage you refer to?

(*Mr. Bidder.*) I do not know why my learned friend interrupted me, but that is not the same thing as he is saying now, although the two things are not inconsistent.

10,280. (*Chairman.*) I understand you to say in sea water the proportion of nitrogen to carbon is as 1 to 1.5?—Yes.

(*Mr. Bidder.*) Say two to three.

(*Witness.*) You will see that sometimes it is actually 1 to 1, and less than 1 to 1.

10,281. (*Mr. Bidder.*) You have put in Table No. 2, which summarises the results of all these analyses from Teddington to Purfleet, and indicates the increasing ratio of nitrogen to carbon as you go down the river? Yes, and then rises again at Erith, for there again Erith comes in, in an exceptional manner as it does over and over again.

10,282. Is it not the case that when you analysed the mud in the river you found an opposite result, that the ratio of the nitrogen to carbon ruled if anything less as you went down the river?—I have no doubt you are correct.

10,283. (*Mr. Bidder.*) I am now referring to a table which will be found on page 561 of Dr. Tidy's evidence upon the Mud Inquiry of 1880.

(*To the Witness.*) To make it clear to the Commission, those are muds I think?—Yes, those are muds.

10,284. And they range from a good way up above Teddington; they go up to Clewer and then they go down to Erith?—Yes.

10,285. The ratio of the nitrogen to carbon, you gave up in the whole region above Teddington as 1 to 5·2?—In the muds.

10,286. In the upper tidal reaches it drops from 1 to 10·4 to 1 to 1·77, which it is in the lower tidal reaches? Yes.

10,287. So that in the Mud Inquiry the result of many analyses was that the ratio of the nitrogen to carbon was less in what you charge as the polluted section of the river, than it was in the pure water above Teddington Weir?—That was so. I daresay you will remember we had a great deal to say about that, but I think it was capable of explanation.

10,288. It wanted a great deal of explanation because it was contrary to what you were insisting upon?—No, pardon me there.

10,289. I will turn to your evidence?—But read it all.

10,290. Do you deny that you said upon that occasion an increasing ratio of nitrogen to carbon was indicative of pollution?—No, but you will remember that there was something to be said about the high ratio of the nitrogen to carbon in the higher reaches.

10,291. I have no doubt you would have had something to say to it, now I referred a little time ago to the startling and anomalous variations of the free oxygen. I think I may, with equal confidence, refer to the same table as showing an equally violent variation in the ratio of the nitrogen to the carbon?—I think you may.

10,292. If the Commissioners will turn to Table No. 17. "Samples of Thames water taken at Erith," we shall see how, either from the admixture of sea water, or for some reason or other, the ratio of nitrogen to carbon varied at the same place at different times for instance, you give four observations upon the 28th of October, you give the organic carbon and you give the organic nitrogen in consecutive columns, now I do not know whether you can answer me, the first one gives a ratio of 1 to 4·5, that is at 10 o'clock?—Yes, it is so.

10,293. The one of an hour and a half later gives you 1 to 3·2?—Yes.

10,294. The one at four in the evening gives you 1 to 4·1?—Yes.

10,295. And the one at five o'clock gives you 1 to 2 within an hour at the same place?—I presume so, I did not take the samples.

10,296. Take another,—October the 30th, the one I referred to for another purpose, the low water one gives 1 to 3·5, and the other 1 to 5·2?—Yes.

10,297. Of course you would say that is what you would expect because it was sewage, now the next day gives you just the reverse, the low water one gives you 1 to 5·4, and the high water one gives you 1 to 3·6?—You cannot tell anything about the sewage because they let it in at all times.

10,298. But you cannot at high water at Erith get sewage because there is no mechanical arrangement by which we can send sewage down to Erith upon the flood?—I have seen it let out at dead low water.

10,299. But we cannot send it down to Erith against the tide, so you cannot suggest that we can increase the ratio of the nitrogen to carbon by letting out the sewage against the tide?—It might have gone out at low water and come back again.

*Dr. C. M. Tidy, M.A., M.B.*

27 Feb. 1883.

10,300. (*Lr. Stevenson.*) Are these samples taken at absolute high water and absolute low water, or at the higher and lower tides respectively?—I do not know.

10,301. (*Mr. Bidder.*) When I speak of high water I do so inferentially from the analysis itself. Now I have the Nautical Almanack; upon the 31st of October, it was high water in the afternoon at London Bridge at 5—1, therefore down there it would be about 4·30, so it would be as near high water as anything could be, so that there are two successive days, upon the one of which you get the ratio of nitrogen to carbon reduced from 1 to 3½ to 1 to 5 by the high water coming in at flood tide, and upon the next day exactly the opposite result is produced, the low water being 1 to 5½, and the high water being 1 to 3½?—That is so.

10,302. I suppose you cannot suggest any reason for it?—I cannot.

10,303. Then what value is there in a ratio which can fluctuate in that enormous proportion and fluctuate directly contrary to the direction in which your theory should make it fluctuate?—I cannot explain all the circumstances under which these fluctuations occur, it is utterly impossible to do that.

10,304. Surely you will admit that the last fluctuation is diametrically opposite to what your theory would require, will you not?—One never knows exactly what is the position of things with respect to the discharge of sewage, or when it is going out.

10,305. Am I to go over that again and point out that the tide was rising?—But perhaps some had gone out which was coming back again. I do not know how much of what has gone out is coming back again, and it is a very fair inference.

10,306. Having drawn your attention to that, I leave it there, the next thing I have to ask you about is this, I will come to the big table presently in detail, but you said that the result of Dr. Letheby's experiments, as recorded in the printed book of 1856, was to show in the old sewers 56 grains of matter in solution and 38·15 in suspension?—I did not take it out of that book. I took it absolutely from the results in the laboratory book.

10,307. Will you refer to this book, page 125 (*handing to the Witness the Report of Messrs. Bidder, Hawksley, and Bazalgette, of* 1857?—I am bound to say I never saw this book, because it is one of the things I have wanted to get hold of and been unable to do so.

10,308. Excuse me, because I have already cross-examined you upon it on one occasion. What I want you to look at is that Table No. 13, which you see brings out the total of 38·15 grains of suspended matter, the very figure you have given us—it is divided into "soluble constituents," and "suspended ditto"—the soluble are given as 55·74 upon the average, and the suspended at 38·15?—It does look so.

10,309. I am not right in saying that those are the very observations upon which your evidence was founded?—No, it looks so, but I took mine from the laboratory book itself.

10,310. From Dr. Letheby's book?—Yes.

10,311. Those are Dr. Letheby's Tables?—Yes.

10,312. (*Chairman.*) You were Dr. Letheby's assistant, I think at that time?—I was.

10,313. (*Mr. Bidder.*) Now, I will ask you this—have you noticed that there is one thing which makes that, I will not say an unfair, but an unreliable, deduction—that is to say, you have averaged together very large sewers and very small sewers; for instance, the Commissioners have before them the Fleet Sewer with an average flow of 1642 cubic feet a minute, and the London Bridge Sewer with a flow of 1396, and on the other hand there are included some small sewers with a flow as small as seven feet and even four feet a minute. Then again you will notice the sewers which are heavily charged, especially the one which as regards soluble constituents raises the average enormously, is a very minute one; viz., the Town Dock sewer, which has a flow of even less than five feet a minute?—Yes, but the sewerage system must consist of large and small pipes.

10,314. But I ask you, does it appear to you a fair way of getting at the constituents of London sewage to take big and little sewers, and to average them as being all consisting of sewage of a certain constituency?—It would not have been fair to have taken the system as consisting of all large sewers, or to have taken the system as consisting of all small—I think taking the average is a fair way to do it.

(*Chairman.*) How does this bear upon the present inquiry?

(*Mr. Bidder.*) You must ask Dr. Tidy; he introduced it.

(*Chairman.*) He did not put in this table in any way, did he?

(*Mr. Bidder.*) Dr. Tidy put in the results of that table.

(*Witness.*) It looks like it, but I am bound to say I had never seen this exact table in my life.

(*Mr. Bidder.*) If you will refer to question 9879, Dr. Tidy was asked this question. "Tell us first of "all, if you please, what amount of matter in solution "you find in the London sewage, what sewage you "are taking for this purpose." To that he says in the course of his answer: "I have looked up a very "large number of experiments which were made, and "inasmuch as I was engaged upon them myself during "the time I was engaged as assistant to Dr. Letheby, "I may refer to them. I have here the analysis of a "gallon of sewage taken from 10 of the large City "sewers, I cannot exactly give their names, but they "were 10 of the large City sewers; the average flow "at mid-day from which is marked as 349 gallons per "minute. It was during the time I was assisting "Dr. Letheby as medical officer of health to the "City that those were taken." Then he says: "Now, "taking mid-day sewage, there was an average of 94 "grains of solid matter per gallon, of which 56 grains "were in solution and 38·15 grains in suspension; "of that 94 grains 31 grains were organic, 15 grains "of that organic matter were in solution, and 16 grains "in suspension."

10,315. (*Chairman.*) You might have had, if not this table, at any rate the contents of this table present to your mind?—I have very little doubt that it was so, only I still say I have never seen this table before. I had before me a much larger body of facts bearing upon this question than this table shows; indeed I went so far as to say I did not know the sewers I was referring to.

10,316. (*Mr. Bidder to the witness.*) You did. Now I will put what I was trying to put in another way, which I am sure you will answer. You say the matter in solution is 55·74 grains?—I did not say that. I said the results which I had looked at gave that result.

10,317. The result you draw from the experiments?—From the experiments recorded in the laboratory book, from which evidently this table is constructed, but whether all the experiments were used or not, I do not know.

10,318. It would not have been the fact, would it, if you had thrown the sewers into one common sewer, that the united sewage would have had anything like that amount of suspended matter, because upon the average the strong sewers are the little ones, and the weak sewers the big ones; for example, if you take the Fleet, which has nearly half the total flow, you will find that that contains 44 grains of soluble constituents, whereas that little Tower Dock sewer, which has a flow of only four cubic feet a minute, has a soluble constituent of 890 grains.

(*Chairman.*) There is a footnote about the Tower Dock. You will see by that note that the Tower Dock sewer is excluded owing to the peculiar composition of the sewage.

10,319. (*Mr. Bidder.*) I beg pardon, I had not noticed that. (*To the witness.*) Now, passing to the suspended matter; you have taken in the Custom House west sewer, which is represented as having

78·49 grains of suspended matter; that only discharges 22 feet in a minute?—Yes.

10,320. The Custom House sewer, which only discharges 22 feet a minute, contains 78 grains of suspended matter, whereas the two big ones at the head of the list, which contain nearly nine-tenths of the whole sewage, contain only 29 and 22·44 respectively?—That is so; but seeing, as I said before, that you do not have the large sewers all at one place, and all the small ones at another, it seems fair, if you are going to take the average, that you should take large and small together.

10,321. It is not the result you would have arrived at if the water of all these sewers were poured into one sewer?—I am not so certain of that.

10,322. If there are 10 parts of one grain and one part of 30 grains, the average would not be 20?—But at the same time I do not know the length of the small sewers and the length of the large. Before I give you an average upon that basis, I must know the length of the small sewers and the length of the large, because the question is, what is the composition of the sewage when it reaches the outfall.

10,323. But you have given a certain result as from these experiments. I only put it to you that it is an incorrect result from these experiments?—I do not admit that it is not, but I would go further and say this: that it is a result which practically coincides with or is not very far off from the results obtained by the Rivers Pollution Commission.

10,324. (*Chairman.*) This is not the witness's table, to begin with, and therefore we do not quite understand the meaning of this table. You have here the Fleet sewer given as 1642 for the average flow per minute, and the soluble constituents 44 grains; is that per gallon?—Yes.

10,325. (*Dr. de Chaumont.*) In making up the average from the results which you had before you, did you take simply the arithmetical average?—Yes, I did.

10,326. You did not make any allowance for the quantity of sewage coming from each sewer?—I did not, upon the ground, which I say I believe is the correct one, that the sewage of London is made up out of large and small sewers; therefore I believe that is a fair way of doing it.

10,327. (*Mr. Bidder.*) Now I have it clearly, that when you gave those figures as the result of this experiment you took the simple arithmetical mean of the figures without any regard to the length or the size of the sewers?—Exactly.

10,328. Again, that was only the average of the mid-day sewage?—That was so.

10,329. And under no circumstances would it be representative of the average sewage of the 24 hours?—No, it would not represent night sewage, and it would not represent storm sewage; the night sewage would be very much less, and the storm sewage would be immensely greater, therefore I have taken that mid-day sewage as in some wise representative, that is to say, neither taking the very extreme of storm nor the very weak night sewage.

10,330. But storms are casual and seldom, but night is a thing which comes once in 24 hours?—But may I just say, my own experience is that the greater effects of storms infinitely over-balance the diluting effects of night.

10,331. I am coming to that, but at present, if you cast your eyes on that same book, back to the table before Table No. 12 in the Report——

10,332. (*Chairman.*) Your evidence in answer to Questions 9879 and 9880 was substantially based upon the information given in those tables?—It looked so, clearly; but, as I have said, I never saw those tables before.

10,333. (*Professor Williamson.*) And not merely the facts, but the facts used in the same way as they were used in by the compiler of the table?—Quite so. I am bound to tell you I only turned to the laboratory book.

10,334. (*Chairman.*) Upon looking at those tables and those averages, you would admit that they were not reliable?—I am afraid that there are no absolutely reliable results, unfortunately, and therefore we have to do the best we can. With regard to the whole question of what is the composition of sewage, changing as it does with every storm, and changing between night and day, the only way in which you could get an absolute result would be to take a certain quantity, say, every half-hour during a year. I wish to state very clearly that I do not put these forward as absolute results; they cannot be; no results can be, I am sorry to say.

10,335. (*Professor Williamson.*) Let me put this to you. You will understand that it is not a question of the validity or otherwise of the special observations here quoted, it is rather a question of the use to be made of them in taking what is called an average, that is to say, taking equal quantities of these various sewages from both large and small sewers, and arriving at a certain number of grains to a gallon as though they were supplying sewage in equal quantities; that is something very different from an average?—All the table does is to show that in a certain number of sewers a certain quantity of sewage has been collected, that sewage contains so much suspended and so much dissolved matter, and the totals are added up and divided by the number.

10,336. (*Mr. Bidder.*) But your 38·15 grains multiplied by the total quantity of sewage in these sewers would not represent the quantity that was in them?—No.

10,337. (*Professor Williamson.*) An equal number of samples would not represent an equal amount of sewage?—No.

10,338. (*Mr. Bidder.*) If you were to take the total number of gallons a minute and multiply it by your 38·15, you would not get the average quantity of suspended matter, or anything like it?—Certainly not.

10,339. Now Dr. Letheby gives in the previous table the result of his analysis of the night sewage?—He does.

10,340. In which we see the effect of the night in modifying the day sewage; and this is subject to the same observation, that he is using arithmetical averages; that which he made 38·15 by day comes to 13·99 by night?—That is so.

10,341. Now we pass from Dr. Letheby and his experiments to some others. Have you worked out, even accepting that figure of Dr. Letheby for night and day, what would be the average for the whole 24 hours?—I have not.

10,342. However, now to come to something more immediately relating to the present time; you told us you had yourself made observations relating to sewage at Barking and Crossness, and I understand your result is that the sewage delivered at Barking and Crossness contains an average of about 25 grains to the gallon?—Yes; that is to say, omitting storm sewage.

10,343. Shall we call it the normal sewage; will you find any fault with that?—No.

10,344. I think you have increased your estimate since I had the pleasure of examining you before upon this subject; you then put it at 22 grains?—I put it at from 23 to 25 grains, I think.

10,345. I think you made it 22. At question 6009 I asked you, "What is the total number of grains to "the gallon you have found during your observation "of the sewage. I think, if I understand right, it is "about 22 to 23 grains to the gallon," and your answer was, "I think that must be about it"?—I think I should rather have said 23 to 25, but still it does not much matter.

10,346. Now, I understand you to say that the increase during the time of heavy rain and storm in your judgment raises that; of course we know it must raise it, but raises it until it is equal to 44 or 45 grains; what is your ground for that statement?—My first ground for that is the experiment of Dr. Frankland. In the report of the Rivers Pollution

*Dr. C. M. Tidy, M.A., M.B.*
27 Feb. 1883.

Commission, page 29, Dr. Frankland gives a series of analyses, and although I am quite aware that you may take objection to one or two of the high numbers, nevertheless, it gives an average of between 45 and 50 grains. Then, secondly, during a storm our own experiments gave some very high numbers, which numbers in the main (there was a little discrepancy, owning, no doubt, to the different times in which we obtained the sample or the different condition in which we obtained the sample) were agreed to by Mr. Keats. And I would just say that Dr. Frankland and myself, upon the 30th of December, if you look at the answer to Question 6227 upon the Mud Inquiry, found 119 grains of suspended matter in a gallon, whilst Mr. Keats admitted that he found even 95 grains. No doubt there was a litte difference in our sample.

10,347. I think you must be referring to Question No. 6256. I think I put it to you that you or Dr. Frankland found 119 grains in the samples in the Fleet sewer, and we could only find 95?—No, excuse me, the 119 grains was not found in the Fleet sewer, it was found in the Northern Outfall.

10,348. You are right?—So that in the sample which was practically agreed to by the Metropolitan Board of Works we found 119 grains of suspended matter.

10,349. (*Professor Williamson.*) Was that in a period of storm?—Yes; but the point I am trying to make clear at the moment is that, though I admit 25 grains to be the normal amount of suspended matter in a gallon, yet the time when we get storm sewage is when we bring up the average enormously by the increase of suspended matter.

10,350. (*Mr. Bidder.*) You have no record, have you, of the duration of that 119 grains flow?—No.

10,351. You know it is very short, do you not?—I am quite aware of the facts that were brought forward, but at the same time I only say that such was found.

10,352. It is something more than a detail, is it not; it is a fact, is it not, that, taking that one occasion, the 119 grains flow only prevailed for an hour or so, and within a very short time had dropped down to the normal?—I do not think you are justified in saying "an hour or so," I know exactly the experiment you are referring to, and I must say I do not think you are justified in saying "an hour or so."

10,353. If you will look at page 975. Question 10,164, Mr. Keats was examined, and the question was put by the umpire: "There seems to have been "also a quarter of an inch on the 31st," and his answer was, "That is the point: I want to direct "your attention to that. On the 30th a quarter "of an inch of rain fell and brought down 95 grains "of solid matter in the sewage. But then on the "31st there was again a quarter of an inch of rain, "but it brought down no extraordinary quantity of "matter to the outfall"?—No, because the first storm had washed it out. Now I venture to refer to the circumstance you have just referred to. I would ask you to refer to Question 9980 on page 954. You will find that it was in the 24 hours after that it fell to 28·2, and not within an hour.

10,354. I did not say it fell to 28, but I said that it fell within 24 hours to the normal?—No, I beg your pardon, you said it fell within an hour or two to the normal. Now the next fall to 20·62 grains per gallon was after 48 hours. It is not a question of hour by hour; it is a question of day by day.

10,355. That is to say, there having come a storm which washed out the gutters and swept out the refuse it fell in 24 hours to 28, and in the second 24 hours, it fell to far below its normal?—Manifestly that must be the case, because the whole theory of storm sewage is that a large quantity of material collects in the pipes, and then a storm comes and washes it out, and then it must fall below the normal; then it collects again—another storm comes and washes it out.

10,356. That observation you have drawn my attention to, shows that there was a temporary rise to about 100 grains, and that is succeeded by a rapid fall, so that within 48 hours the sewage has fallen below its normal?—Quite so.

10,357. That being so, have you any observation from which you can deduce that the excess in this time of heavy rainfall more or appreciably more than balances the subsequent defect?—No, and I know of none that can absolutely prove it, except that I am quite sure that to take 24 or 25 grains a gallon, does not give a fair result.

10,358. So that when you said last week you put it between 40 and 45, you had no basis for that statement?—I did not state it as between 40 and 45, I gave a much broader number, because I know the extreme difficulty of giving such opinions.

(*Chairman.*) At Question 9983 you said "I take it "that as the normal quantity from 23 to 25 grains "may fairly be put down, but taking all the rest of "the year I doubt if it would come out at less than "from 45 to 50.'" Then I appear to have asked you, "That would include the storm sewage?" To which you replied, "Yes. In the report of the Rivers "Pollution Commission we have a sample containing "164 grains per gallon, and I have myself found "more than that, so I do not think we are taking "an excessive quantity."

10,359. (*Mr. Bidder.*) Now let me dispose of Mr. Keats's report to the Rivers Pollution Commission as affecting this matter. What is the date of that report?—1870.

10,360. What is the date of the observation?—February, March, and April, 1869.

10,361. You have referred in confirmation of your view to the first report of the Rivers Pollution Commission, and to the tables upon page 29, which are all based upon observations in the years 1867, 1868, and 1869, is that so?—No; I am only taking the results of observations taken on February the 23rd, 1869.

10,362. Taking 1869 only, then, are you not aware that these observations were made before the general introduction of catch pits for the purpose of intercepting the road drift?—No, I am not indeed.

10,363. One can readily understand if that is so, that the introduction of catch pits throughout London generally for the purpose of intercepting the road drift, would make a material difference in the amount of suspended matter in that sewage?—I do not admit anything of the kind.

10,364. You do not admit that the introduction of catch pits would make any difference in the amount of suspended matter in the overflow?—I do not say that it would make no difference, but that it would not completely alter the matter. But that is not the only high number I can give. I would like to draw attention to Question 6240 in the Mud Inquiry (that was Dr. Frankland's evidence, but I think I may take the responsibility of it at the same time), where it is stated that from the Fleet Sewer's storm outfall we obtained 447 grains of suspended matter.

10,365. You did, and do you recollect what happened—do you recollect we insisted upon having the man who took the sample, and that it turned out that he had been scraping up the mud with a tin can—scraping a hole in the mud?—I do not remember that; I do not admit that; I do not believe myself that the 116 grains per gallon is anything like the quantity that comes down in the storm sewage.

10,366. I think we may now pass to your big table, because I have some questions in detail to ask you upon it, and alongside of your big table, we may take the next Table, No. 2, which is a condensed summary of the results which you consider material in Table No. 1, or at least of some of the results; I want to ask you this first with regard to that table: there is no doubt, is there, that the condition of the river as regards free oxygen, nitrogen and carbon, ratio, and various other things very much depends upon the time of the tide?—I do not know how much it does.

10,367. But it must more or less?—To a certain extent.

10,368. You would expect it to, would you not?—It may.

10,369. You have divided this table in your summary into five sections?—Yes.

10,370. In which you show the progressive diminution of free oxygen, and with the exception of the last, an increase in the ratio of the nitrogen to carbon. Is it not the fact that in four of those sections, 1, 2, 3, and 5, all the observations were taken at low water, whereas in the 4th section, which is in the middle, the observation was taken at high water, the amount of chlorine will show it you by itself?—Section No. 1 is taken about $1\frac{1}{4}$ hours before high water.

10,371. I do not mean upon the actual turn of the tide?—I should like to go through them all, first to see how far they are correct, because I do not think they are altogether. I have every one marked, and I think it might be worth while doing so. No. 1 was taken at 1 hour 15 minutes before high water.

10,372. That is at Teddington?—Yes. No. 2 was taken at three hours after high water. I have considered every one of these points, and I think it right to mention that before I gave in this table, I distinctly stated that it was so, that I had taken cognizance of the fact.

10,373. Perhaps I may be wrong as to the top ones, but begin at the other end; take your 5th section where the tide is of importance?—I would say that No. 54 was taken $3\frac{3}{4}$ hours before high water. 55 and 56 were taken 2 hours and 30 minutes before high water, and so on. I do not think that will assist you much, because I do not believe that Erith will assist you much in the case.

10,374. All those are taken nearer low water than high water, are they not?—For instance, No. 58, the last one that I took was 3 hours and 50 minutes before high water.

30,375. That is nearer low water than high, is it not?—It is.

10,376. When I come to the next section, from 43 to 53, those are all nearer low water than high water?—They are a little.

10,377. You have only given the time of one of them, but I will tell you why I put the question to you because I look at the quantity of chlorine?—You are quite right in that respect, but at the same time, I do not think you are absolutely right, though I cannot give you the time.

10,378. I will take it that I am substantially right? My own impression now I think of it is, that you are wrong.

10,379. If you look at the table it is a very startling thing. Now, in the next section above, from No. 36 to 42, the samples are all apparently taken near high water, because the chlorine is greater than in the section below?—Yes, I quite admit that circumstance.

10,380. If I am right in that, and that is what I wish to suggest to you, that your third section is taken nearer high water, and all the rest nearer low water, it very much vitiates the result drawn from a comparison of the various sections, does it not?—It gives you a general idea. Comparing the amount of chlorine, the free oxygen, and the ratio of the nitrogen to carbon, it shows that there is no such vast difference as you would suggest.

10,381. Take the third section and let us see if there is no great difference between Greenwich and the Albert Dock and the first section. We have at Woolwich, 327·4 of chlorine, at Charlton, 307·8, at Charlton Ballast Wharf, 303·8, at Clyde Wharf, 292·0, at West India Dock, 256, at Greenwich Royal Naval College, 225, that is the top of the section, then we rise to the next section, Deptford, 37, Millwall, 25, off Sewards, 17, at the Tunnel Pier, 9, in a line with the Monument, 2·8, that is at London Bridge, and so on?—I mentioned before I put in the table that the samples were taken at different states of the tide.

10,382. How can you suggest to the Commission, that they can with any confidence, draw any comparison between the amount of free oxygen and of chlorine and salt, and so on, from samples so taken?—I think I mentioned that the proper way to take the samples was an impracticable way, viz., to have a series of people along the river taking them at the same time.

10,383. But how does it happen that we get some of them taken at high water, and some at low water?—I think I can explain that by saying, that I took them on different days.

10,384. Let me draw attention to another inaccuracy; if you look at Table 2, you will see the amount of free oxygen per gallon in cubic inches, and having got that down to ·8 you represent that in the fourth section as ·717, as being the average of the observations from 43 to 53. What you say is "Beckton to Crossness 43 to 53 free oxygen ·717"?—It ought to be.

10,385. Now there is a more serious mistake, one of these numbers, No. 44, is a sample of sewage from Beckton, now is it a fair thing, as a sample of the River Thames, to give an actual sample of the sewage?—It is not, and I should not have put it in, if it had struck me, but I think it will make very little difference.

10,386. It does indeed. Now I will draw your attention to another, No. 43 is as bad or rather worse, and is taken from the immediate neighbourhood of the Beckton sewer?—But that is a part of the River Thames.

10,387. But that is a water which is immediately affected by the locality of that sewer. Now would you be surprised to hear that if you only correct the amount of free oxygen by taking out the Beckton sewage, that will show us a better figure than in the reach above. I will leave that to you to answer to-morrow. Now I will mention another thing, this table of yours shows another very singular thing does it not; and that is, that there is a remarkable polluted section which we have nothing to do with. If you look at Nos. 29 to 35, which embraces that part of the river from Blackfriars Bridge to Deptford, if we look at the matter in suspension, especially the organic matter, we shall see, that whereas above Blackfriars Bridge the total matter had ranged from two to eight and nine grains per gallon, yet that particular section, in a most startling manner, shows 18, 15, 15, and 19 grains per gallon?—Yes; they were taken on different days.

10,388. That shows that it was not peculiar to one particular day?—Let me point out that in that polluted section which you are referring to, the samples were taken entirely upon June the 21st, and that high rate of matter in suspension seems to be peculiar to that date in some way or other.

10,389. Is it so, because upon the 21st of June, whereas at Blackfriars Bridge you find 15 grains, upon the same day at Lambeth Bridge you find only eight?—There is a difference, but still all these samples in this polluted section were taken upon the 21st of June.

10,390. One is taken upon the 11th of July?—You are quite correct.

10,391. Now is not that very strong evidence rather of a source of pollution operating upon that section,—whether it be drains or docks, or whatever it may be,—which is quite independent of the Metropolitan Board of Works outfall?—Will you allow me to refer to the table? I notice that, taking the percentages of organic matter in that series which you are referring to.

10,392. That they are very high?—There are two numbers high, two moderate, and the rest fairly normal.

10,393. You mean to say that though the quantity of grains is more, you do not think the quantity of organic matter is more?—There is something else I want to note, and that is that so far as the organic carbon is concerned, it is not very high certainly.

10,394. Let me follow that up; you put it to me that though the quantity of suspended matter has increased very remarkably, it does not follow that the organic matter has; now I ask you to refer and you

*Dr. C. M. Tidy, M.A., M.B.*

27 Feb. 1883.

will see that the organic matter, according to your own showing, is three times as much in that section as it is generally in the river?—Pardon me.

10,395. Take first, for instance, Blackfriars Bridge, No. 29; there are 15 grains there?—Of what?

10,396. Of suspended matter, of which 18·50 per cent. is organic matter?—Whereas I draw your attention to this, that at Westminster Bridge, No. 28, there were only 7 grains of matter in suspension, of which also 18 per cent. was organic matter.

10,397. I am giving you the whole section; if you take Blackfriars Bridge there are 15 grains and 18·50 per cent. (I will not take the trouble to work them out, you can work them out by to-morrow morning) that is 2·8 grains of organic matter?—That is so.

10,398. Now the next, No. 30, is 4·9 grains of organic matter; No. 31 is 2·8; No. 32 is 6·8; No. 33 5·2; No. 34, 4·5; and No. 35 is 2·5. The average of those you will find is 4·2 grains of organic matter, whereas if you take a general line of the others above and below, it ranges about 1·5. Now, if those figures are right, can you explain how in the reach from Blackfriars Bridge to Deptford you find not merely an increase of the organic matter, but really a trebling of the quantity of organic matter?—I am not able to account at the moment for the reasons, there may be engineering reasons for it.

10,399. (*Mr. Lumley Smith.*) There is a storm overflow coming in at Blackfriars, is there not?—I think that might account for it very likely.

10,400. (*Mr. Bidder.*) But when we were discussing the evidence of gentlemen from Deptford, we found bad smells when crossing in the steamer from Greenwich. Is it not a remarkable fact, that we find treble the organic matter there that we find in the neighbourhood of the outfalls?—I would say that that which renders the water emphatically the most impure, is that which is present in the form of soluble matter.

10,401. That is not the thing which the people smell in the steamboats if they do smell anything?—There is no doubt about there being something to smell, but I say you must not judge of the purity or impurity of the water by the amount of suspended matter.

10,402. How do you account for the remarkable or comparative absence of free oxygen in the section from Putney to Vauxhall?—I do not know.

10,403. It is very remarkable, is it not?—It is. There is organic matter going into the river and we know there is a constant contest going on between the organic matter and the oxygen. Sometimes the oxygen has too much work to do, and sometimes it is just balanced, and we get those variations in that way.

10,404. You agreed with me that to some extent the condition of the tide would affect the results shown here. Just let me, as some index of that, as one element, draw your attention to this: the lowest section, the Erith section, will show you as an average about ·5 of a cubic inch of oxygen?—That is right.

10,405. Your large table ranging over a considerable period at Erith shows under different circumstances oxygen to more than treble that quantity?—It is so undoubtedly, that is to say, that if the sea-water gets up there, in which the oxygen has not been called upon to do a great amount of work, then you get the oxygen in a much larger quantity. I do not give that as an absolute explanation of the discrepancy.

10,406. I am now upon this question: how far the result of these tables taken upon one day, the 6th of July, can be taken as an indication of the general state of the river; your result from this day is ·5 of oxygen, whereas your result over a long period of observations extending over a fortnight shows that ·5 is quite exceptional?—I have stated that it was difficult to draw conclusions about Erith.

10,407. But I have pointed out that your ·5 is a very exceptional and unusual condition?—I do not admit that.

10,408. I venture to say that the average amount of oxygen in Erith is about 1·2; should I be wrong in saying that?—I dare say not, which means perhaps that a very large quantity of sea water has come in, and that the call upon the oxygen of that sea water has not been such as to get rid of it.

10,409. You gave the Commission some evidence with regard to the constitution of the sewage itself, you emphasised the number of tons of dry excrementitious matter in suspension, and in solution?—Yes.

10,410. And I believe, if I understood you correctly, those results were based upon certain German observations?—Not entirely. I gave you Messrs. Röder and Eickhorn's observations upon urine.

10,411. Here again the figures are so startlingly identical, that I cannot help thinking (you will tell me if I am wrong) that I have identified your authority and theirs, and that they are both taken from a common source of observation, they take it from Woolff and Lehmann, do they not?—(*After referring to a book.*) They do. I just want to say that I have taken the urine from Röder and Eickhorn because I have no doubt that is about correct, but there have been a good many researches as to the quantity of fæcal matter that should be taken per head; therefore I have not altogether taken Messrs. Röder and Eickhorn's numbers.

10,412. Will you just refer to that report (*handing a book to the witness*) and see if I have not tapped your source of information: look at the number of men, women, boys, and girls out of the 100,000?—That is right enough.

10,413. I think if you look there and follow it out, that somehow or other you have some mistakes in your arithmetic, and that you have brought out results which, although you employed them, were somewhat exaggerated. In the first place as regards the fæcal matter they give a result of less than yours?—I would just say I have not taken Messrs. Röder and Eickhorn's calculations as regards fæcal matter, I will say at once that there have been other observations taken since then upon an English population, and I should say, perhaps, by one who knows a great deal about it, and one whose views are very clear upon the subject, that is Professor Way. He takes what I think is really a very fair estimate, namely, about 1,750 grains as the quantity in England of fœcal matter passed per head, including men, women, boys, and girls to the number stated by Messrs. Röder and Eickborn.

10,414. But do not throw over your authority so entirely, directly I have found out where it is?—But I told you where it was. There was no attempt on my part to conceal where I got it from.

10,415. Will you kindly tell me whether, if you adopt the figures given by your authority as to the result from 100,000 people, that does not give a very different result?—I will tell you what I make it.

10,416. Will you tell me if I am not right in taking the fæcal matter for the whole of London at 90 tons per day?—It would be 94 tons.

10,417. And the dry soluble matter if dried, would be about 185 tons?—No, I do not think you are quite justified in saying that. I would just say that the quantity I have taken as the solid matter in the urine, I have taken from Professor Kirke's book.

10,418. I would like to have it from the same authority as you relied upon previously?—I have not relied absolutely upon the other.

(*Chairman.*) I see Messrs. Woolff and Lehmann's Book is dated 1880. What was the date of Messrs. Röder and Eickhorn's work; was it a book published before 1880?

(*Mr. Michael.*) It is the same thing, one is quoted from the other.

10,419. (*Mr. Bidder.*) Mr. Röder quotes from Messrs. Woolff and Lehmann. Messrs. Woolff and Lehmann are the original authorities. (*To the witness.*) I think you will find you have taken the fæces twice over?—I wish to put it quite clearly.

10,420. You gave 100 tons as the insoluble?—

I gave 111·6 tons as the total, and of that 100·5 tons insoluble and 11·1 tons soluble. Then I took 2½ ozs. a day as the solid dry matter of urine; that calculated out, comes to 282·3 tons. 282·3 tons added to 111·6 tons is 393·9 tons, and I said 400.

10,421. I beg your pardon; you said something a good deal more than 400, you said 444?—It is 444 tons of moist fæcal matter, because I am taking the fœcal matter as containing 75 per cent. of moisture; therefore it is 444 tons of fœcal matter.

10,422. I think I misunderstood you. You will find in your 2½ ozs. of solid derivable from the urine, that you have taken the wrong figure, and that that is the figure which includes the fæcal matter?—No, that is not so. I have taken a great deal of trouble about the matter, and I am prepared upon it at all points.

10,423. Will you take Messrs. Woolff and Lehmann's book. If you refer to that book, you will find that for 4,000,000 of people the quantity of fæcal matter is 185 tons a day?—May I tell you my authority upon this—it is Professor Parkes. Professor Parkes states that daily 1106·9 grains of solid matter are passed in the urine per head of the population; 1106·9 grains is 2·53 ozs.; 2·53 multiplied by 4,000,000 will give you the result I have stated.

10,424. I think that must be taking adults, and I will tell you why. I have given you your rope, now let me have a little rope. If you take the results of Messrs. Woolff and Lehmann in that book from which you get your solid——— ?—No, I beg your pardon I did not take it from there.

*Dr. C. M. Tidy, M.A., M.B.*

27 Feb. 1883.

10,425. At all events you will see they give a certain amount of solid matter from the urine for the 100,000 population?—German.

10,426. One twenty-fifth of that, he says, is solid residuum?—It would come out a little different.

10,427. Not very different, it does not indeed——? —If you divide that by 25 and multiply it by 40.

10,428. (*Chairman.*) Are these figures identical with Messrs. Röder and Eickhorn's?—Yes, they seem to be so. I do not think it will make any vast amount of difference.

(*Mr. Bidder.*) But I do not say that because I have tried it, and I know it does.

(*Chairman.*) If the figures are identical one can work out the sum at once.

(*Mr. Bidder.*) He does not know it and I do. I put it at the time: do they not make 185 tons instead of 283—now I will leave that question. I will not ask you to worry yourself by answering it now.

Adjourned to to-morrow at half-past 12 o'clock.

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# TWENTY-SIXTH DAY.

## Wednesday 28th February, 1883.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

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| COLONEL C. B. EWART, C.B., R.E. | THOMAS STEVENSON, Esq., M.D. |
| PROFESSOR WILLIAMSON, F.R.S. | JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst. C.E. |
| FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S. | WILLIAM POLE, Esq., F.R.S., *Secretary.* |

DR. CHARLES MEYMOTT TIDY, M.A., M.B., further cross-examined.

10,429. (*Mr. Bidder.*) Just let us take up one or two loose ends that we left last night. In the first place you were going to look into that question of the calculation of the amount of dry excrementitious matter, and I have no doubt you have done it?—I have, and I may say that German weights are not English weights, a German lb. is not an English lb. I will give you certain differences that may be worth noting; the Prussian lb. is 1·0311 lbs. avoirdupois; the English lb. is ·9698 Prussian lb., one German zoll lb. is 1·1023 English lbs., and the English lb. is ·90719 German zoll lb.

10,430. The quantities in this book I refer to, are not given in lbs. at all?—They are not.

10,431. They are given in tons or 1000 kilos, which I think is within 1 per cent. of our ton?—I am bound to say having thought the matter over as fully as I can, that although taking Messrs. Röder and Eickhorn's calculations as Germans, there is a certain difference: yet let me say that only brings it down to, I think I am right in saying, 97 tons; it is the difference between 97 and 111 tons.

10,432. What is the other difference?—The other is a greater difference.

10,433. Your 97 is very nearly in accordance with the figure that we ourselves made it?—Therefore, as far as that is concerned, if you like to take it in that way, instead of putting it as 444 tons of moist fæces, it is about 385 tons.

10,434. We are agreed substantially, that the amount of dry matter from the fæces is somewhere about 97 tons; now, I want to go to the other matter, the dry matter in solution?—But, I contend that you did ask me about the quantity of the fæces.

28 Feb. 1883.

10,435. (*Chairman.*) Instead of 111 it will be 97?—Yes; and then again in order to get the moist fæces, which is the actual fæcal matter thrown into the Thames, you multiply that 97 by 4 which brings it to about 385 tons of moist fæces per day, which is Mr. Bidder's own number.

10,436. (*Mr. Bidder.*) I am not asking a word about that; but now coming to the other matter I am asking about, have you corrected the 283 which represents solid matter in solution?—I have.

10,437. What do you make it?—According to that calculation, it is about 197 tons instead of 282.

10,438. That is a little more than I make, but I do not quarrel with it?—But let me say this, that I do not accept it.

10,439. (*Dr. Stevenson.*) Now, I will ask you what amount of dry urine you take per head per diem; you said 2½ ounces; do you adhere to that?—Yes; 1,100 grains is a very fair average for men, women, and children, of which I take about 512 as urea, and the rest as extractors, that is to say, it is 2½ ounces of dry matter from the urine, and one ounce of dry matter from the fæces, and I believe that is very nearly the fact.

10,440. (*Mr. Bidder.*) There is another authority I dare say you are acquainted with. I think you mentioned Dr. Parkes. If you look to page 131 of his work, you will find that he gives 40 ozs. of urine per head?—I think that is a very small amount. I

*Dr. C. M. Tidy, M.A., M.B.*

28 Feb. 1883.

really think 40 ozs. a low calculation for the quantity of urine per head.

10,441. (*Dr. de Chaumont.*) How many ounces do you take?—I make out, that taking adults, male and female, 60 oz. is about the quantity as near as possible. I am aware that most modern books give 50 oz.

10,442. But we are dealing now with a mixed population, both adults and children?—Then I think 40 oz. is a very fair number.

10,443. (*Chairman.*) What would you say, taking units of the population?—Taking units of the population, I think that 40 oz. is a fair number.

10,444. (*Dr. Stevenson.*) In answer to Question 9,907, have you not taken very nearly 40 oz. as the basis of your calculation?—Yes, I have. I have taken the population calculated upon Messrs. Röder and Eickhorn's views, that is to say, a population of 100,000 contains so many men, women, and children, from which I get the figure I have given.

10,445. (*Colonel Ewart.*) Have you thought over the question of the time required for putrefaction?—Yes, but I should not like to give you an answer at once. It is a difficult question to answer; it is more difficult to answer than would occur at first sight.

10,446. (*Mr. Bidder.*) I think there is one point in which all the authorities agree, that the proportion of urinal matter that you get dry is 4 per cent.—that is what Messrs. Woolff and Lehmann say,—one twenty-fifth?—I think that seems somewhere about it. I am not sure that I can give it you exactly.

10,447. I think you were mistaken just now in telling Dr. Stevenson that you had taken 40 oz. in your previous calculations, because, if you will take 4 per cent. of 40 oz., that gives you 1·6 oz. of dry matter, but you told the Commission that it was $2\frac{1}{2}$ oz.

10,448. (*Dr. de Chaumont.*) But did you take 4 per cent.?—I did not. I said that off-hand I could not say. (*To Mr. Bidder.*) I do not accept your number.

10,449. (*Mr. Bidder.*) But just let us get the figures right, and then we may arrive at it?—But I am not accepting the 4 per cent.

10,450. But you agree to the 4 per cent., surely?—I do not indeed.

(*Chairman.*) One of my brother Commissioners, who has a knowledge of this subject, tells me that one of the authorities gives 4 per cent., another gives $4\frac{7}{10}$ths, and another gives as much as $6\frac{7}{10}$ths per cent.

10,451. (*Mr. Bidder.*) I think I am right in saying that Messrs. Woolff and Lehmann say 4 per cent., and I see that Dr. Burdon Sanderson, who is an authority upon this subject, says also 4 per cent.?—I think that 4 per cent. is too low, decidedly.

10,452. (*Chairman.*) There appear to be various authorities, some saying 4 per cent., some $4\frac{7}{10}$ths, and some $6\frac{7}{10}$ths per cent., and I believe Dr. Tidy takes the highest figure?—No, I do not at present; still I agree that the matter requires a good deal of consideration.

10,453. (*Mr. Bidder.*) At all events, you will agree with me, that if 4 per cent. is right and 40 oz. are taken, then your $2\frac{1}{2}$ oz. becomes $1\frac{1}{2}$?—Of course, the whole thing is a matter of calculation. I still think that mine is very nearly the right figure.

10,454. I put some figures upon your Table No. 1, and I hope you will accept them from me for the present, and afterwards you will be able to check them if I am wrong, about the increase of organic matter in a certain part of the river. First, I would ask if you have checked those figures?—I have not checked them.

10,455. Now, I want you to go to another matter. The quantity of fœcal dry matter being as much as you say, and the quantity of sewage being, as we know, or practically we may say, 26,000,000 cubic feet per diem put into the river, have you considered the extent of the dilution which that undergoes?—No, I have not.

10,456. Are you aware that it is about $\frac{1}{240}$th of the volume of water into which it is thrown?—I have not calculated it.

10,457. But is not that an important question?—I do not think it is; it is the addition of sewage to sewage; it is not the addition of sewage to fresh water; if it were the addition of sewage to fresh water, it would be important, but it is not that.

10,458. (*Chairman.*) You have not calculated it?—I have not.

10,459. (*Mr. Bidder.*) Assuming Mr. Mansergh's figure to be correct, will not that tell you what is the amount of dilution?—I have not been into that at all.

10,460. I wish you to go into it now?

(*Chairman.*) I think that to ask the witness in cross-examination to deduce general principles from the calculations which have been made by another witness, is rather carrying cross-examination too far.

(*Mr. Bidder.*) I ask the witness a particular question; to look at the volume of water into which the sewage of the river is discharged as calculated by Mr. Mansergh, and to tell us the amount of dilution it undergoes.

(*Witness.*) It is a calculation that you will do very much more rapidly than I can, and I will accept your figure.

10,461. I give you that figure subject to your checking it?—I will accept it for the purpose of the question.

10,462. I will give the figures to you so that I shall not trouble you. I will take September 14th, at high water. You see that the first column of that table of Mr. Mansergh's gives the content of the river at high water at certain sections; now you are aware that the sewage is, subject to the exceptions which have been referred to, poured in at the ebb tide?—It may be. I saw it going in at low water.

10,463. I said, "subject to certain exceptions"?—I was down there at low water and saw it going in, and I dare say it goes in every day.

10,464. The amount of water which goes past upon the ebb and upon the flow of the tide, is about 30 miles?

10,464A. (*Chairman.*) Do you know that?—I do not know anything at all about it.

10,465. (*Mr. Bidder.*) Will you accept it from me?—I do not know anything at all about it.

(*Chairman.*) You are furnishing the witness with a problem of which he has no personal knowledge whatever.

10,466. (*Mr. Bidder.*) He was here when the figures were put in. Mr. Baldwin Latham showed that the flow and ebb of the tide was about 30 miles. Now taking from Crossness, 13 miles above it, taking two sections above Crossness and a portion of another section, you find you have over 3,000,000,000 cubic feet to flow out with the tide; do you follow me?—I do not, indeed.

10,467. Assume from me that that is so, that shows a dilution of $\frac{1}{240}$th part?—A dilution of sewage with a little weaker sewage; yes.

10,468. You may call it a little weaker sewage if you please, but assume the sewage is put into something like 240 times its volume of river water?—Certainly, I can not.

10,469. (*Chairman.*) You are requested to assume that?—I will assume it, but I do not admit it.

10,470. (*Mr. Bidder.*) I do not want to catch you in a trap. I only give you the way the figures are arrived at, and I do not wish you to vouch for the accuracy of the calculation. Assume that the sewage is discharged into that volume of water?—No, that I do not admit.

10,471. Say a volume of liquid, at any rate?—Say sewage water, if you please.

10,472. I will call it liquid, 240 times its own volume; therefore it follows that your suspended matter in the sewage comes to a tenth of a grain per gallon in the river?—I do not know that.

10,473. If you have 25 grains in a gallon originally, and you put it into 240 gallons of water, it comes to

one tenth of a grain per gallon practically?—Yes, that I accept.

10,474. Have you also examined what your organic carbon and nitrogen in the sewage are with the view of ascertaining what portion of that which you find in the river is accounted for by the sewage?—No, I have made no calculation of the amount or percentage of the sewage in the river at all upon any occasion.

10,475. Was it not worth while to try?—No, it was not.

(*Chairman.*) This gentleman is a chemist, you know.

(*Mr. Bidder.*) And I am asking him a chemical question. If you mean to suggest that chemists are incapable of making the simplest calculations, I must protest against it. I know many chemists who are very clever arithmeticians, and I know that Dr. Tidy is not an exception to the rule. No man can be a successful chemist unless he is a good arithmetician.

(*Witness.*) Then I say at once I have made no such calculations; and I would prefer to make that clear, as I know that other questions would be asked upon it.

(*Chairman.*) We understand you to be here to give certain chemical evidence to the Commission.

(*Mr. Bidder.*) We suppose Dr. Tidy to be here to give valuable evidence to the Commissioners.

(*Witness.*) If it had been a question of the admixture of sewage with river water, I should have been competent to deal with it; if it had been a question of the admixture of sewage with sea water, I should again have been competent, perhaps, to have formed an opinion as to quantity; but when I have certain unknown factors with unknown quantities of three things, I do not feel myself, with those facts, at liberty to make any estimation of the quantities of sewage in the mixture; and, therefore, in questions of that nature, I gave my results, and others gave their results to the engineers to supply by sectional areas, which we had not, and which we were incapable of dealing with, details which I did not feel myself prepared to discuss.

10,476. But you have had the assistance of engineers upon your side, and have been in the room while they have been giving evidence. Do I correctly understand that you have not thought it worth while to make use of the figures which have been supplied to you as to the volume of the river so as to form any judgment as to what is the extent of dilution, and how far the outfalls of the Metropolitan Board of Works account for the defilement of the river?—I did not consider it my duty to do it.

10,477. (*Chairman.*) You did not consider it to be your duty?—If I had considered it my duty, I should have done it.

10,478. (*Mr. Bidder.*) Was it no part of your business as a chemist to have done it?—As a matter of fact, I have not done it. There were other matters to be taken into consideration, sectional areas and such like, which were not within my province.

10,479. (*Chairman.*) There must be some check to this cross-examination. You are cross-examining a chemist, and are going into the province of an engineer. You are, I think, therefore departing from the province of an expert chemist, and are examining upon questions of engineering.

(*Mr. Bidder.*) I am very sorry I have not made my question intelligible to you or to the witness, and I take the blame to myself. I am examining Dr. Tidy, not upon any question of engineering, but I am examining him entirely upon a chemical question. The question upon which I am cross-examining Dr. Tidy is this: Whether, having regard to the chemical facts upon which he has been dilating, and the results at which he has arrived, he has taken the trouble to compare the volume of water with the mass of materials which comes from the sewers, so as to be able to tell the Commission whether he believes the sewers are or are not the cause of these chemical phenomena.

(*Chairman.*) He says he has not.

10,480. (*Mr. Bidder to the witness.*) You are not prepared to say whether they are or not?—No, I do not know anything at all about it.

10,481. Now let me ask you this, and we will take care to keep very strictly within your province; you have described to the Commission a large quantity, so many hundred tons, of organic matter which goes into the river; I ask you, as a chemist, what becomes of that?—I have given a certain account of what becomes of it. I have said that, as regards, first of all, the insoluble matter, it floats about.

10,482. (*Chairman.*) This has all been given before?—I have dealt with all this. Some of it, I said, combines with aluminous compounds; it decomposes.

(*Chairman.*) You have given that answer, and need not give it again.

10,483. (*Mr. Bidder.*) You divided the sewage, I think, at any rate, you did upon another occasion, into that which continues to float about in the water (or, perhaps, "floating" is a word which does not cover it all, either floating, suspended, or carried in solution) and that which sinks to the bottom. One may divide it fairly that way. All the polluting elements of sewage must either in the run of the river sink to the bottom or else they must remain in the river as matter in suspension or matter in solution or dissipate into gas?—That is quite so.

10,484. Now, excluding for a moment that which sinks, if there is any, and which becomes part of the mud of the river, and confining the question to the other, in your belief is it not entirely consumed, that is to say, burnt up?—Eventually. Excluding the part that goes down to the bottom, the rest is oxidised.

10,485. And you would say absolutely annihilated?—Finally disappears. "Oxidised" means burnt up.

10,486. (*Mr. Abernethy.*) But if it is repeated day by day, does it disappear?—There is a good deal more to come out of this. That is just the point.

10,487. (*Mr. Bidder.*) You say "eventually." I put it to you, within a comparatively short time?—I am not going to admit that, unless you give me the precise conditions under which the admixture takes place.

10,488. The conditions I give you are those of the sewage?—Then I say, no. What I have stated over and over again is in regard to an admixture of sewage with pure running water.

10,489. I am quite sure you will not depart from what you said before?—No; I have nothing to withdraw upon this question

10,490. You have gone into this question of sewage and animal pollution a good deal?—Yes.

10,491. Let me ask you if you find anything to modify in the opinions you have expressed in this pamphlet, "Tidy, on River Water"?—"The two "questions we have to discuss are, first: Does the "water of a river, having been once polluted by "admixture with sewage, again, after a moderate "flow, assume its original state of purity? In other "words, does running water possess any power of "self-purification? Secondly, if such natural process "there be, what are the conditions requisite for its "fulfilment, and what are the circumstances affecting "those conditions? Let me briefly state my case, "and then proceed to call my evidence:—1. If "sewage be discharged into running water, the "organic impurities will, I contend, after a flow of a "few miles, be entirely destroyed or got rid of, the "water once again assuming its normal condition of "purity. 2. That this power of self-purification "depends upon three things: (α) On the *susbsidence* "of the suspended impurities brought down by the "sewage. Thus, in the course of the river-flow, the "grosser suspended matters will be left behind. "(β) On the presence of *animal life* in the river. "After the water has assumed a certain degree of "purity (for it is not till then that animal life "thrives), the fish in the river act as river scavengers, "and so as general purifying agents. (γ) On the

*Dr. C. M. Tidy, M.A., M.B.*

28 Feb. 1883.

" *oxidation of the organic matter.* The dissolved " oxygen is derived partly (and, in the first instance, " entirely) from the air, and partly (more especially " in the later stages, when the water has reached a " certain purity, and vegetation begins to reappear) " to plant life, vegetation constituting an important " means whereby oxygen is set free in the water " itself; such oxygen is, probably, in a more than " ordinarily active condition to effect the oxidation of " the organic impurity."

After a short discussion with respect to these passages being read to the witness as the basis of questions, the Commissioners having consulted together, the Chairman stated that, although it was not evidence within the strict principles of law, the Commission would permit the passage to be read.

10,492. (*Mr. Bidder.*) I will read a short passage upon page 35, and ask you if it does not describe exactly what is taking place in this section of the Thames. It is the passage headed: " *The naked eye* " *inspection of rivers receiving sewage.*" " If we " examine a river at, and a little beyond, the spot of " sewage discharge, it will be observed that the " admixture of the sewage with the water of the " river is, at first, more or less imperfect, the line of " the sewage stream being distinctly marked for " some distance. Gradually we shall note the sewage " path widening, the edges becoming less and less " defined, until, after a certain run, the exact distance " being dependent on many circumstances unnecessary " to specify now, the mixture of river water and " sewage will be complete. But there is more than " this to be noted. The sewage at the outfall is " probably offensive, very turbid, and more or less " brown, the exact colour and degree of offensiveness " being dependent partly on the character of the sewage, " but chiefly on the distance it has travelled along the " mains before its discharge into the river, and the " extent of exposure it has undergone. Tracing the " sewage stream down the river, it will be seen to " assume a black colour, from the formation of sulphide of iron. A further short distance, and the " black colour perceptibly decreases, and, as we watch " the flow, the blackness, I had almost written yard " by yard, disappears, until at last the river water " exhibits no signs of colour, turbidity, or smell. " Once again, very soon after sewage has been turned " into a river, the sewage fungus, that most absolute " indication of the presence of sewage in any quantity, " makes its appearance in the river. Excepting this, " however, all signs of vegetable life, barring possibly " a few straggling weeds, disappear; no fish, or fish " only of a certain kind, are to be seen. The banks " and river bed become black, and branches of any " trees that by chance dip into the water, will be seen " covered with a black floculent deposit. A short " distance further down the river (and, sometimes a " very short distance indeed) the sewage fungus can- " not be found, vegetation becomes clean and luxuriant, " fish are abundant, and the river banks and the river " bed seen through the now clean water show no " signs whatsoever of that black deposit observed " higher up the river." Now, is not that the very thing that you see at Barking and Crossness?—It has not anything to do with it at all.

10,493. (*Chairman.*) Does not that description fit what you see at Barking and Crossness?—Not at all.

10,494. (*Mr. Bidder.*) Is not that what takes place in cases where the proportion of sewage is far greater in relation to the pure water than it is in the Thames?—It does, undoubtedly, take place to an extent.

10,495. But with a far greater proportion of pollution?—I do not know what the proportion of pollution is.

10,496. You instanced one case; you say, " I have " seen the River Soar, at Leicester, black with sewage; " no river vegetation being visible. I have seen it " the day following at Loughborough (a distance of " 13 miles down river from Leicester) perfectly clear, " the river banks clean, and fish abundant "?—That is quite true.

10,497. That is to say, that 13 miles run is sufficient?—Yes.

10,498. " I have seen the River Irwell, at Man- " chester, polluted with every form of filth, personal " and manufacturing. At Warrington, after a flow " of nine miles, the offensive character of the stream " had entirely disappeared "?—Yes, except that I think nine miles is wrong. I think it ought to have been 13 miles.

10,499. (*Chairman.*) Has that any bearing upon the matter?—None whatever.

10,500. (*Mr. Bidder.*) If you think that has no bearing, let us come to something that has some bearing. I will refer to B., upon page 37; " From " this appeal, to the naked eye inspection of rivers, " let me pass to certain analytical results. There is, " first of all, a remarkable fact to be noted in the " analyses of Thames water. The water at Lechlade " may be regarded as having assumed, as nearly as " possible, the character of river water. Up to this " point it will be conceded that, practically, no sewage " has found its way into the river. Between Lech- " lade and Hampton, a distance of 110 miles, the " river received (I am speaking of a few years ago) " the sewage of nearly a million people. At certain " places it is admitted that a larger quantity of " organic matter, than was present at Lechlade, could " be detected in the water. For instance, one mile " below Reading I have found a quantity of organic " matter at least double that indicated at Lechlade; " but four miles further on the water was again found " to have become normal, whilst the organic carbon " and nitrogen at Hampton, notwithstanding the " sewage of this million of people, was rather less " than at Lechlade. What, I ask, had become of the " sewage of this million people, if it had not been " oxidised during the flow of the river?" Now let me ask you a question; you do not draw back from any of these statements?—Not in the slightest.

10,501. It is the fact, that the flow of the river water of this very Thames which you are taking as the standard of purity, and which they are giving to all London to drink, has received the sewage of a million of people?—Yes, but I am speaking of a few years ago.

10,502. (*Mr. Abernethy.*) That is a non-tidal portion of the river, and the current is always flowing in one direction?—Quite so; it has nothing to do with the case.

10,503. (*Mr. Bidder.*) If the water is flowing, is there any virtue in water flowing from east to west, which there is not in water flowing from west to east?—Not the slightest.

10,504. Do you suggest that there is any advantage in a flow one way rather than in a flow both ways?—Not the slightest.

10,505. Is there any alteration in the million?—Yes, a considerable alteratton.

10,506. Is it less, or more?—It is very much less. I am not speaking exactly, but I believe it is not a tenth part of what it formerly was.

10,507. (*Mr. Abernethy.*) What is the date of that report?—That report was written in 1880, but that fact had reference to some years before.

10,508. (*Chairman.*) All these towns in the upper valley were drained subsequently?—Yes.

10,509. (*Mr. Bidder.*) Notwithstanding the drainage of this million of people (really equal to a quarter of London), the water, when the sewage was in it, was drinkable water at Hampton?—Yes.

10,510. It was not only drunk, but, in your judgment, it was drinkable water?—Yes, but I object to sewage going in.

10,511. Still it was drinkable water?—I think, as a rule, it was.

10,512. Let us get the figure into our mind, a quarter of the sewage of London?—Yes.

10,513. The water over the Teddington Weir is about seven times the volume of the sewage of London, that is what the engineers tell us?—It varies.

*Dr. C. M. Tidy, M.A., M.B.*

28 Feb. 1883.

10,514. Therefore, there is a dilution of 1 in 28?—Yes.

10,515. So that in the very Thames water, whether it be that the conditions are altered now or not, one part of the sewage to 28 of river water produced, by the time it got to Hampton, a drinkable water?—Yes. That has nothing whatever to do with the question, but still I admit all that.

10,516. If I am right in my figures, what we are doing at Barking is putting the sewage in at the rate of one part in 240?—I do not admit that.

10,517. How am I wrong in drawing that inference?—As regards the mere question of quantity?

10,518. No, not the mere quantity. Why are not the same principles applicable at Barking as were applicable at Hampton?—That, of course, raises the whole question.

10,519. That is the very reason why I asked it.

(*Chairman.*) We have had it in evidence, I think, that there has been 30 days' sewage in the river at the same time.

(*Mr. Bidder.*) But what I want to point out is, that that is upon the assumption that the sewage is not destroyed. You see how the argument of the other side turns upon itself in a circle. Our argument is, that the sewage is burnt up; but the assumption on the other side is, that nothing of the kind takes place, but that once sewage, always sewage.

(*Professor Williamson.*) It is a question of words; I think the engineers apply the word "sewage" to that liquid, whatever its compositlon or condition; whether it is much changed is another question, but they refer to that liquid.

(*Mr. Bidder.*) Professor Williamson will follow me, I know, in what I say. Supposing one day's sewage has been put into the river, and has been destroyed absolutely as sewage, and the oxygen restored in the water, that is, in no sense, in the way of the next day's sewage. If I make myself intelligible, the question is, whether or not the previous sewage is out of the way; and the engineers, when they said there was 30 day's sewage in the river, assumed, as I put it, in so many words, to Mr. Mansergh, "once sewage always sewage." It was a mere mechanical deduction, assuming that the 1,000,000 gallons of sewage put in at Barking, remained there for ever.

(*Dr. Stevenson.*) On the other hand, if you assume it is diluted 240 times, that supposes that the sewage, every 24 hours, is conveyed out to sea.

(*Mr. Bidder.*) That is quite right, but I should answer it by saying there are two tides in the day.

(*Witness.*) Now, I think, Mr. Bidder asked me a question, which I am prepared to answer. The question is, why are not the same principles applicable here? Now the whole of this pamphlet refers to a non-tidal river; it refers to the admixture of sewage with pure water, and I have distinctly stated that by "pure" I certainly do not mean "salt water." I certainly do not mean "salt water." I certainly do not mean water in which the free oxygen has been reduced to a minimum, or almost so. Thirdly, I do not mean a water in which there is no vegetation.

10,520. (*Chairman.*) Those are three reasons?—But I have not given them all.

10,521. (*Mr. Bidder.*) Before we go from that, taking these assumptions, I will discuss how far we depart from them, and how far they affect the question; but I think you have repeatedly expressed the opinion that given those conditions, the percentage of sewage that you can put in is $\frac{1}{20}$th of its volume?—I think that was stated upon the 14 mile run.

10,522. You and Dr. Frankland have had some severe passages of arms upon this subject?—And it is right to say that Dr. Frankland does not agree with me in this.

10,523. I will only read the last passage in this pamphlet (*referring to the pamphlet called "River Water."*) It summarises it all admirably, and I will ask you if this is not true, and if not, how far it differs. "Given, then a fairly rapid river that has received "sewage in quantity not exceeding, say, one twentieth "part of its volume, is there evidence to prove that, "after the run of a few miles, the water of that river "will regain its purity, and become wholesome and "good for drinking? To this question I answer "unhesitatingly, there is undoubted evidence of such "purification, and the evidence I have adduced has "been of a fourfold nature: physical, chemical, "medical, and statistical." That is Dr. Tidy's parting shot at Dr. Frankland.

10,524. (*Chairman.*) Has that anything to do with a tidal river?—Nothing whatever.

10,525. (*Mr. Bidder.*) You are good enough to say that this has nothing to do with a tidal river. Why are not the same chemical processes at work in a tidal river as produce that result in a non-tidal river?—For this reason: we have, first of all, a water of a very different composition. You cannot call sea water "pure" water; you cannot call a water containing 2,000 or 3,000 grains of common salt per gallon pure water; it is a non-drinkable water. That is one thing. And though I admit that I have no absolute experiments in proof, I think it is a matter of common knowledge that salt has a certain preservative action. How far that preservative action is exerted in this case I do not know; still it is common knowledge that salt has a preservative action. Then secondly, the river is tidal, it is going backwards and forwards, that is to say, the sewage is not poured into pure water, which is the principle upon which I have been dealing; and I have in that pamphlet, which I should have liked all to be read, in summing up my conclusions said, that the primary dilution of sewage by pure water is the essential principle of the whole thing.

10,526. (*Chairman.*) The learned counsel says, why is there a difference between the pure water and the tidal river water? And you say that the presence of salt is one great reason, that it has a preservative action, and so interferes with the decomposition of the sewage; is there any other reason?—Yes, because the sewage goes into this water and renders the water itself a kind of dilute sewage. The result is that it is the pouring of sewage into sewage, and it is not an admixture of sewage with pure water. A further thing is that when that water is running in one direction, there comes a time when plant life appears; and I have always attached in this process great importance to plant life. Plants as you know set free oxygen, I do not say to what extent, but there is no doubt that (I do not use the word in the sense of raising a discussion), in a nascent condition, oxygen has an activity which it does not possess afterwards. Then we find, as a matter of fact, that the free oxygen which is in the water of the river opposite these outfalls is in comparatively small quantity, and I say again, although I have not brought forward evidence of this (but I shall, I was asked to do so), that a small quantity of oxygen has not the same activity as a large quantity, even bulk for bulk, that is to say, quantity for quantity. No doubt the particles, if they are in solution, are more separated, and absolute contact is obtained with greater difficulty, so that practically this is not a case of dilution of sewage with pure water, because it is dilution of sewage with sea water. Secondly, it is not a dilution of sewage with a water which is free from sewage, because it has contained large quantities of sewage, and the oxygen in the water has been exerted in burning up the sewage that it contained.

10,527. (*Mr. Abernethy.*) I gather from you that your observations are applied to a stream of pure water?—Yes.

10,528. And not to sewage poured into a volume of mixed salt and fresh water constantly oscillating?—No.

10,529. And not to water moving constantly backwards and forwards?—No; but in the river Thames a certain amount of oxidation no doubt does occur.

10,530. (*Mr. Bidder.*) Do you suggest that oscillation is any way adverse to the process of oxidation going on?—To this extent, that there is not the same amount of purity kept up.

*Dr. C. M. Tidy, M.A., M.B.*

28 Feb. 1883.

10,531. You distinguish these opinions so as not to be applicable to the present case, by saying, "I assume pure water." Take one of your instances, the river Irwell, that you mentioned; is that a pure water where the sewage comes in?—Where the sewage came in originally, it was.

10,532. But where the sewage you speak of comes in at Manchester, is it a pure water?—No.

10,533. Is it not far more polluted than the Thames?—I do not know.

10,534. (*Mr. Abernethy.*) Do you know that the Irwell is dammed at Warrington?—Yes.

10,535. And that, below that to Liverpool it is a wide tidal estuary?—It is; I know it perfectly.

10,536. (*Mr. Bidder.*) Is not the Irwell, at the place you take as an illustration, were the sewage is discharged into it, a far more polluted river than the Thames?—It is; it is worse.

10,537. And yet the process of purification goes on?—Yes; but that has nothing to do with it. I am supposing the sewage poured in above the dam.

10,538. (*Chairman.*) It is pure water in the sense, that it is not tidal water?—That is so. It is true I was speaking of the sewage that went in at that spot, and there was sewage that went in at a spot above, and therefore it was really impure water at the point in question, but still I take it as a running water having a continual flow.

10,539. (*Mr. Bidder.*) I thought by "pure" water, you meant "unpolluted" water. Now we will keep "unpolluted" distinct from "non-tidal," and I will ask you separately. As far as "pure" means "unpolluted" previously with sewage, the Irwell, which is one of your sample cases, is a far more polluted river than the Thames; you admitted that to me?—I would not say that.

10,540. But you said it was, just now?—I will admit it might be, but I tell you I will not say it is distinctly so. I quite admit it is blacker, and looks more so, but I think that has something to do with dye works.

10,541. Now you say you would rely on vegetation; is there any vegetation below Manchester?—Yes, it does appear lower down.

10,542. Does it appear as much as upon the Thames?—Yes; I can assure you there is a great deal more.

10,543. Now, taking the tidal points, you said that when you have a deficiency of oxygen, the oxygen that remains is less energetic in its action; have you any observation, whatever, that supports that view?—I would put it in this way, in fact I did put it so, that if 2 cubic inches of oxygen have a self-purifying power equal to 4, 1½ cubic inches have not a self-purifying power equal to 3.

10,544. That is not quite what I mean; I ask, have you any observation, experiment, or result which supports that view?—I have.

10,545. What are they?—One of the learned Commissioners has asked me for them, and I have promised to bring them to him, but it is really tabulating over 5,000 analyses, according to the organic carbon, and the free oxygen present, and it is a matter of considerable labour.

10,546. (*Dr. Stevenson.*) If, as I understand, you take the Thames water as containing 2 inches of free oxygen in winter, and 1½ in summer, do you find any difference in the activity of those quantities?—I am not able to say that I do, at the moment.

10,547. Do you think that the winter oxidation is the more powerful, or the reverse?—In the summer we have vegetation, and light more active; and there is no doubt that the oxidation is then more active; but I should not like to say the exact influence of these agencies. I certainly have a very large body of facts bearing upon that question.

10,548. (*Mr. Bidder.*) You think you find the oxidation more active in summer?—Yes.

10,549. But that is when there is the lesser quantity of free oxygen?—That may account for it; that the oxygen is used up in burning up the organic matter.

10,550. That is quite the converse of what you have stated when you said that when the free oxygen was less its activity was disproportionately less?—But it has been used up probably by burning up the organic matter.

10,551. That is, doing its work?—I am not saying it is not.

10,552. Now I will pass to another question. Your Table No. 1., which you put before the Commission, unfortunately stops at Purfleet?—It does.

10,553. Why did you not carry it further down?—There is an immense deal of labour involved in doing these things.

10,554. Would not another thing have been shown if you had, viz., that as you go below Purfleet, the oxygen of the river immensely increases?—It must; there is no doubt about that.

10,555. If I might roughly represent the amount of free oxygen by a curve, I should, at Teddington, have a curve like this (*sketching a rough diagram*); then, growing very small past the outfalls, and regaining its position below Purfleet?—Yes.

10,556. Does not that mean that the oxygen has been doing its work, and that before it has got to Southend its work is complete?—Yes; but all the sewage is not discharged in that way, if you could show that it is all got rid of in that way ——

10,557. But I am putting it to you, whether it has not ceased to exist by the time it has come to Southend, and therefore does not require to go out? Before I leave this question I will show you this. If you take one of your tables, I think it is No. 10., which goes lower down the river, it is manifest that, as you go down the river, there is a recovery of the free oxygen?—It is so.

10,558. (*Chairman.*) With regard to that additional oxygen which you would find towards Purfleet, where would that come from?—I should think from the sea water.

10,559. (*Mr. Bidder.*) And also by aeration to some extent?—Yes, to some extent, possibly. There are some very curious points which I do not wish to say too much about at the moment; but there is this remarkable fact, that when you have over a certain amount of organic matter in a water, its capability of taking in oxygen is singularly reduced. And there is another very curious point, that if you take very deep well water (I have examined a great deal of Southport water, which is taken from a very deep well) when that water comes to the surface it is absolutely wanting in free oxygen, but it recovers itself and becomes saturated with oxygen in a very short time. The presence of organic matter itself changes the rapidity with which water takes in oxygen in a very curious manner.

10,560. (*Mr. Bidder.*) If the Commission will compare Table No. 1 with No. 10, they will see on Table No. 1, which begins at Teddington, that up at Teddington, although we begin with a fluctuation, yet it is practically about 1¾ inches of free oxygen. That goes down with fluctuations, as this table shows, until at the outfalls it is down to ·7, and according to that table, at Erith, down to ·5?—Yes.

10,561. Then if we go to Table 10, and carry the thing on, Table 10 gives no low water on a certain day. North Woolwich is the highest point there, and is fairly accordant with Table 1. I will take the "one foot below the surface at low water," 1·15 of free oxygen, and then in the next place the southern main drainage outfall.

(*Mr. Lumley Smith.*) That ought to be a little higher in the table; is it out of position.

10,562. (*Mr. Bidder.*) At that part it is ·58. Then we go to Erith "one foot below the surface at low water," ·62; and then at Gravesend "one foot below the surface at lower water" ·66; and then, if we go to Southend one foot below the surface, it is 1·2?—Yes.

10,563. That justifies, as I say roughly, my curve?—Yes, I admit that.

10,564. I want to ask you, as a chemist, the signifi-

cance of this curve, does it not mean that the water charged with oxygen has been doing its work burning up the organic matter in the water, and that before it has got to Southend, the oxygen has mastered the sewage; the sewage is decomposed, and therefore the oxygen rises to its normal?—Yes, when the sewage does arrive at Southend, I am bound to say that I think a great deal of it is mastered.

10,565. (*Mr. Abernethy.*) Is not the river at Southend a wide tidal estuary?—Yes, very much so.

10,566. With an enormous body of pure sea water flowing in every tide?—It is so.

10,567. (*Mr. Bidder.*) I am obliged to Mr. Abernethy for pointing that out. (*To the witness*). That wide tidal estuary supplies the water which comes up the river every tide, and that is pure sea water?—I do not call it pure sea water.

10,568. (*Mr. Bidder.*) Let me refer you to page 580 of what you said upon a former occasion, upon the Mud Inquiry. At question 5921, I put this question to you: "Given the state of the Thames and "the brackish water, there being two hundred "volumes of water to one day's sewage, it will be "burnt up," and your answer was, "Yes." Then Mr. Aston, another of the counsel put to you this question again: "All the suspended parts will be burnt up, you say" and your answer is, "Yes"?—I could not have meant that from any point of view; I must have misunderstood your question.

10,569. (*Chairman.*) You say it would not be burnt up?—Not entirely.

10,570. (*Mr. Bidder.*) Your own counsel puts it to you "All the suspended parts will be burnt up"?—I am sure I should not have said yes to that.

10,571. But you did. Upon that occasion you were trying to fix us with the responsibility for the mud. You were not then dealing with the suspended particles. You were trying to show that that which did not sink, but remained suspended was burnt up, and that the balance sank?—It does get burnt up in time, no doubt, but when I am made to say that where there is one part of sewage to two hundred parts of water it will be burnt up, I could scarcely have meant that.

10,572. (*Mr. Abernethy.*) What part of the Thames do you refer to?—The part of the river where the sewage was put in. I do not particularly object to that as a matter of fact, because I should accept it generally.

(*Mr. Michael.*) You are talking about oxidation by the air of the river.

(*Mr. Bidder.*) Now, I want to get another thing which we have not got before the Commission. In the peculiar circumstances of the London sewage, a very large portion of that fæcal matter, in your judgment, is burnt up long before it gets to the outfalls at all?—I think some of it is. I never said a large portion of it is; I have no doubt I said that a primary putrescence took place.

10,573. Pardon me; Mr. Bramwell, one of the arbitrators, was examining you?—Which question was that?

10,574. That was at 5901. Now I will refer to question 5885. I asked you, "Speak of the thing as a whole as you are so fond of doing," and you replied, "I cannot take the numbers, that which goes to the "bottom is no doubt oxidised slowly, but very slowly. "(*Q.*) That which did not go to the bottom?—(*A.*) "That which did not go to the bottom is no doubt "carried backwards and forwards, and no doubt does "become oxidised, provided it has a sufficient run. "I have never fixed a run of less than seven miles "upon any occasion. (*Q.*) Do you suggest it has "not a sufficient run in the Thames?—(*A.*) No. I "am bound to say this, that every particle of sewage "which is in suspension in the water,—I will put it "this way if you like,—I honestly believe, is entirely "destroyed long before that water reaches Hampton"?—That has nothing to do with the tidal portion of the river; that is at Hampton.

10,575. No doubt that is so; but look on a little farther. Now, I go on at No. 5888 to ask you with regard to the sewage in the Thames: "Then, similarly, "discharged sewage into the stream of the Thames "at high tide, which has got six hours' ebb—say two "miles an hour—14 or 15 miles run, into 200 times "its volume of water, may I say there, in your belief, "every particle of sewage matter is destroyed by the "time the tide is down?—(*A.*) No, I am not prepared to say that, that is another point of view. "First of all we have not pure water to start with. "The material first of all comes in and pollutes it, "and it gets worse a great deal, and the result is we "get different conditions." Then I asked you, "According to you it gets worse and worse?" and you replied, "Yes." Then Captain Galton asked you this question, "Does the salt in the water—the "brackishness of the water—of the Thames, affect "the question of the decomposition in the lower "reaches?" to which you replied, "It does to some "extent." Then Mr. Bramwell asked you the question, "Which way?" and your answer was, "It "prevents decomposition, no doubt, to some extent. "There is another thing; a great many of these "samples have no smell, as a rule I may say there is "no smell. There is no doubt about it. In the first "instance one was rather struck with that fact, but "on further consideration it was quite clear that one "of the reasons why that should have no smell was "first of all the peculiarity of this sewage, which we "do not find in large towns generally. It has to "travel a very considerable distance before it reaches "the outfall. In other places, as a rule, the people "live immediately on the banks of the river, and "there is very little or comparatively no distance for "the sewage to travel. That is the first fact. The "result is that in all sewage matter there are very "different forms of organic matter. There is an "organic matter which is highly putrescible, where "putrescence sets in immediately, and that organic "matter that is so highly putrescent is divided by an "absolutely sure line from another kind of organic "matter in which the putrescence is comparatively "slow, and there is a third kind even which I have "noted, where you get, after the second putrescence "has set in, a distinct line of demarcation, and then "putrescence sets up again. Now, it is a very "curious fact that when that sewage is discharged at "the outfalls of the Metropolitan Board it has flowed "a very considerable distance. (*Q.*) Six or seven "miles?—(*A.*) Nine miles, we will say; the primary "putrescence is very nearly at an end." Now, notice this, and see if I was not justified in using the phrase I did. Then I asked you, "That is to say, a large proportion has been already burnt?", and your answer was, "Yes; but when it comes out in a very "short time indeed, all the gases are given off, in "goes the water and takes its place, and down goes "the material." So that you were of opinion then, that in the case of London sewage, by the time it got to the outfalls a large portion of the organic matter was already burnt up?—Yes, a large portion was, and I accepted it in that sense. It is not true, but I accepted it.

10,576. (*Chairman.*) Is it true?—The phrase, "a large portion," is a very indefinite phrase.

(*Mr. Bidder.*) It means more than half.

10,577. (*Chairman.*) Do you adopt this unreservedly?—I should not like to say that "a large portion" had been already burnt.

10,578. (*Mr. Abernethy.*) How can you account for the organic matter of the sewage being burnt up within the sewers?—I think this refers to primary putrescence; putrescence is not oxidation. One is a little disposed, unfortunately, to adopt a question when it is asked.

(*Mr. Bidder.*) But you adopted also a phrase in the question of Mr. Bramwell which meant oxidation, "a large portion has been already burnt."

10,579. (*Chairman.*) By "burnt" you meant

*Dr. C. M. Tidy, M.A., M.B.*

28 Feb. 1883.

"oxidised"?—Yes, by "burnt" I meant "oxidised." I ought not to have accepted the question altogether in that sense.

10,580. Putrefaction and oxidation are distinct things?—Yes, as a matter of fact putrefaction is not oxidation.

10,581. (*Mr. Bidder.*) Let us not quarrel about words. Be it oxidation, or be it putrescence, it is resolved into a gaseous form?—Yes.

10,582. And ceases to exist as sewage in the water?—Yes.

10,583. (*Prof. Williamson.*) Is it your opinion that the nitrogenous matter in fresh sewage is converted mainly into gaseous matter when it reaches the outfalls?—No, but I think that there are in sewage matters of varying putrescibility. For instance, there will be a primary putrescence going on in the sewers themselves.

10,584. The urea being converted into carbonate of ammonia?—Yes.

10,585. But the carbonate of ammonia does not evaporate?—No.

10,586. Is there any conversion into gaseous matter worth mentioning in the sewers?—No. But there is another thing which struck me that sometimes the sewage in a sewer smells so strongly and that when it comes out it does not smell, and I could only explain it by the fact that the primary putrescence was at an end. And then I would just say another thing, that at the time I stated that, I had very large quantities of sewage under observation, and I found there was a smell produced for a short time by the primary putrescence, that there was then a period when it did not smell; and that then putrescence set in again as though there were bodies in it of different degrees of putrescibility. That was in my mind at the time.

10,587. (*Mr. Michael.*) You stated that there was a secondary putrescence?—There is what is more curious still; there is a tertiary putrescence.

10,588. (*Dr. Stevenson.*) Would you find that the urea had entirely disappeared when the sewage reached the Thames?—I could not say that.

10,589. Would any great portion of it?—I should not think so; I think some of it would.

10,590. That formed one out of the three and a half ounces of solid matter?—Yes; but I did not use the word "a large portion" myself. It was a question that was put to me, and I certainly adopted it. I must therefore, admit that I did answer in that way.

10,591. (*Chairman.*) You modify that by saying that the word "large" was wrong?—Yes; but of course there was the other point of certain muds not smelling, which was very remarkable; that on taking the sewage from the sewers themselves and operating with that mud before it had passed through a long line of pipes, I found effects of that kind produced, namely, that I got a very disagreeable smell, and then the smell ceased, and so on.

10,592. (*Mr. Bidder.*) Now do not suppose that I want to catch you upon any unguarded acceptance of the question upon a former occasion; but I want to put it to you now, whether you are not prepared to say that that which is burnt up upon the way to the outfall is at least half of the sewage?—I have no facts at the moment to support that statement, but I do not believe it for an instant.

10,593. The river being what it is, and the sewage being put in in the way it is, do you find anything either in this table or in your observations upon the spot or in your experiments, which leads you to believe that the condition of the water or the emanations from the water before it reaches the Thames are injurious to health?—I have not studied the matter from the point of view of injury to health.

10,594. You are an officer of health for one of the London districts, are you not?—I am.

10,595. Before you make any speech will you follow me. I want to put it distinctly before you. You are an expert and a scientific witness, and a health officer, employed in this case to examine the river and take analyses of all kinds up and down the river in the region of the outfalls, and I invite you to tell the Commission whether there is any element of injury to health in the condition of the river?—I say at once that is a point of view from which I have not regarded the matter. I have not sought for statistics upon the subject, but I say that throwing 400 tons of sewage into the river undefœcated, when the whole of the solid impurity could be so easily removed, and the effluent made just as pure as the normal condition of the river, must produce a mass of emanations which I should think, from *a priori* reasoning, must be injurious to health.

10,596. Would you mind instead of 400 tons saying a tenth of a grain per gallon?—No, I say it is 400 tons daily.

10,597. Did you ever know a case in which injury to health was caused by emanations from sewage in the water of a river even worse if you please than the Thames?—Had I thought you would have asked me that question I might have looked it up; but as a matter of fact I have not looked it up.

10,598. Taking your experience of the filthiest river you ever knew, did you ever know such a case?—I have no facts at the present moment upon the point. I have not regarded it from a hygienic point of view.

10,599. But you have been going into these points all your life; have you any experience of the emanations from sewage in the water of a river being injurious to health?—I have none myself; but it is a matter upon which evidence will be offered to this Commission.

10,600. As a whole, what do these concrete observations which you have laid before the Commission upon the main question point to? That there is sewage there we know, and that the sewage is being burnt up by the oxygen we know, but what do they show with regard to the injury to health?—I have no evidence of its being injurious to health one way or the other.

(*Chairman.*) The witness has stated four times that he has no evidence of its being injurious to health, I do not know why you should wish to have it five times.

10,601. (*Mr. Bidder.*) Do you believe for instance from what you find by your chemical analysis or from observation, that the state of the river is injurious to health?—I cannot give you any information at all upon that point

Re-examined by Mr. Lumley Smith.

10,602. I will confine myself to what seem to be the more important matters without going into any great detail in your examination. First of all, with regard to the evidence that you gave based upon the microscope, I shall only put one question to you, and that is whether the results you get from the microscope are in any way what are called quantitative. I think you have already answered that they were not quantitative?—They are not.

10,603. Will you just explain what you meant by that?—That I was unable to say that there was so much sewage matter in this part of the river, or so much sewage matter in that part of the river, and so on, by means of a microscopic examination. Absolutely quantitative they are not.

10,604. Are they in any respect quantitative?—Yes; I said in my evidence in chief that they were relatively quantitative; I made a point of that, if you remember.

10,605. Will you explain a little further what you mean by "relatively quantitative"?—Supposing I start from Barking and take the deposits in the water, and find that from Barking to Deptford I get abundant evidence of free spiral vessels, and of a very large quantity of this yellow amorphous material in every sample; then supposing I go from Deptford to London

Bridge and I find that I get evidence of materially less amorphous matter, and that I get spirals in every other sample; then supposing I go from London Bridge to Battersea and I find the spirals in every fourth sample; I have a relative means of estimating the quantity, although not an absolute means. That is the fact as I stated in my evidence in chief. Starting from Barking and working upwards, the quantity of spiral vessels gradually decreased.

10,606. That I think may enable you to compare different parts of the river, though it does not enable you to know at any part what quantity there is of any particular material?—Certainly not, absolutely.

10,607. The allusion to the microscope brings us to another point. My learned friend, Mr. Bidder, asked you if you had not traced in the water the yellow amorphous material as far as Chiswick, and whether in the mud inquiry you had not traced it as far as Teddington?—Yes.

10,608. He also asked you whether the relation of nitrogen to carbon did not vary in your evidence with regard to the water from what it had been with regard to the mud?—It did.

10,609. Are there any sources of difference between water and mud which would justify you in finding elements of difference between the two?—I do not think the two are comparable.

10,610. The fact that you find an increase or a decrease with regard to the mud as compared to the water does not enable you to compare the one with the other?—No; the one being solid and the other liquid, I do not think you can compare them; they are subject to such different influences.

10,611. My learned friend pointed out upon your table a portion of the river between Nos. 29 and 35, that is between Blackfriars Bridge and Deptford, which he christened "specially polluted?"—Yes.

10,612. As far as matter in suspension is concerned, that appears to be so by your table?—It does appear to be so.

10,613. Does that increase apply with regard to the other columns?—No, it does not. That is to say, taking the organic carbon and the organic nitrogen, they in no way follow the same rule as the quantity of suspended matter; his observation therefore is entirely limited to the suspended matter.

10,614. However, whatever may be the cause it must be due to some local causes?—I think so. I do not know the cause as a matter of fact.

10,615. You are not aware that there are storm sewers or overflows, and so on, in that part of the river?—No.

10,616. Now I will go to what we are told now is to be the platform of the battle, that is, the free oxygen. My learned friend Mr. Bidder put some questions to you as to whether the amount you had given as the quantity of free oxygen at Teddington, which was 2 cubic inches per gallon, was always the amount that was found, and you said it varied from time to time in the year; but referring to your table which is before the Commission, which contains your analysis from Teddington to Purfleet, that is based, I believe, not on an estimate of 2 cubic inches to the gallon, but upon the actual observation of 1·710 at the top of the table?—They are actual results.

(*Mr. Michael.*) We never suggested it was an estimate.

10,617. (*Mr. Lumley Smith.*) That table is based upon the absolute observation of 1·710 at Teddington, that being what was found upon that particular day; and the chart which follows, I think it was No. 3, is based upon the analysis of that table, No. 1?—It is.

10,618. So that neither the table with the analysis, nor the diagram A, depend at all upon an estimate, but upon actual analysis?—That is so.

(*Mr. Michael.*) We never suggested it.

10,619. (*Mr. Lumley Smith.*) If that be so, it seems to make my learned friend Mr. Bidder's questions a little irrelevant. (*To the witness.*) Now, with regard to free oxygen, I presume the experiment has to be carefully made for the purpose of determining the amount of free oxygen in the water?—Yes.

10,620. Now before we pass on, do free oxygen and dissolved oxygen mean the same thing?—Yes.

10,621. It is the oxygen which is not taken up to form the water?—Not combined with anything else.

10,622. I rather understood you to say that it is better to analyse as soon as you can, in order to avoid the risk of fresh oxidation?—Undoubtedly. I should myself have preferred to have examined the free oxygen on the spot. Had bottles been only partially filled and a space left, I should have attached, I will not say no importance, but very little importance comparatively, to the amount of oxygen determined; but as a matter of practical knowledge, I know that if you take it in a certain way, and fill the bottle, you may arrive at it with a fair degree of accuracy.

10,623. It would be better to do it in a boat if it were possible?—Yes; but one heard stories about laboratory boats going down that I preferred to do he determinations away from the river.

10,624. (*Professor Williamson.*) Were they all taken at the same interval after the water had been collected?—Yes; the principle I adopt is to bring the samples home with me and to do them the first thingin the morning.

10,625. The same number of hours intervenes in each case between taking the sample and making the analysis?—Yes, practically. I could not say the same exactly, owing to the different time of the tide; but practically the same number of hours intervenes.

10,626. (*Mr. Lumley Smith.*) With regard to the wave or curve which my learned friend Mr. Bidder spoke of, there is practically rather less free oxygen in the sea water than there is in the water at Teddington?—Clearly; but you may say practically they are the same.

10,627. If you find as you go further down the river that the free oxygen becomes less, that may proceed from sewage coming into the river?—It may.

10,628. I presume it must arise from some local cause or other?—Yes.

10,629. The mere admixture of sea water would not necessarily alter the amount of free oxygen very much?—It would not.

10,630. Then with regard to this wave, if there is a depression in the wave between Teddington and Southend, that would show that, owing to local causes, there had been a diminution of oxygen?—Yes, that is so.

10,631. Then as you get a little further on from the depressed part of the wave, when you find the free oxygen begins to improve, does that necessarily result from the operation of the air, or from the flow of the sea water having come in and diluted the body of impure water that was in the river?—I should think it was both.

10,632. Then it does not necessarily follow that if you find a few miles below the outfall the free oxygen is beginning to improve, that the fresh oxygen has come in from the air, but it may have come in from the sea water?—Yes.

10,633. I find, in point of fact, that your chart No. 1 does not go below Purfleet?—It does not.

10,634. But a little later on we have samples showing the amount of the free oxygen at Southend, and also at Margate?—Yes.

10,635. If you look at your Table 10 you will find that the free oxygen a foot below the surface at Southend pier at low water was 1·21?—Yes.

10,636. That is a good deal less than the free oxygen at Teddington?—Yes.

10,637. The free oxygen at Teddington was 1·7?—Yes.

10,638. So that as far as your wave is concerned the sea end of your wave would hardly get up as high

*Dr. C. M. Tidy, M.A., M.B.*

28 Feb. 1883.

as it was at Teddington?—I very much doubt whether it would.

10,639. If you turn over to the table a little further on you will find the amount of free oxygen at Margate?—That is Table 3, page 4.

10,640. There I find that at Margate the dates are different. They give the amount of free oxygen at Margate as 1·6, which is rather better than at Southend?—Yes. And again, when I take the water at Brighton, it is better still.

10,641. So that if the sea water which comes in at Southend had originally as much free oxygen as water coming in at Margate, it would show that the sea water had been reduced in oxygen by meeting with the Thames?—Yes.

10,642. Now the water does not even at Southend appear to have got up either to the amount of free oxygen that we find at Margate, or that we find at Brighton?—No, it does not.

10,643. I think I might ask you this general question:—As regards going down the river, my learned friend asked you what were, what he called, the "reliable elements" from which you might judge the pollution, and then he took each by itself to see what amount of importance should be attached to each. What is your view with regard to the principal elements to be considered in coming to a conclusion as you go down the river; I presume it is not a simple matter in any way?—What I have stated is that I do not think you can judge of the purity of a water in any way from any single constituent, or from any single detail. You cannot judge it by the organic carbon. I could tell you of an organic carbon of ·9, which is a splendid water. You cannot judge it by organic nitrogen alone, nor by free oxygen alone, nor by ammonia alone; but in every case in the matter of any analysis you must judge of the whole analysis. And let me say, with all due respect to Mr. Bidder, that the details that he dealt with, which I admit do show inconsistencies if you take them in detail, have nothing whatever to do with the case. I look at the water as a whole, and I will refer to this diagram. There is a section in which I admit there is no great alteration in the organic carbon; the oxygen keeps it in check; but I find the organic carbon enormously rises in that section of the river (*pointing to the diagram*), and concurrently with that rise of organic carbon in that section of the river, I have a fall in the free oxygen. It is, if I may be excused for saying so, ridiculous to look at any one single thing and draw deductions from that; you must look at the whole. For instance, in a water 50 grains of common salt may mean nothing; but, on the other hand, even five grains may mean serious pollution. You cannot judge by one single constituent; you can only arrive at a conclusion from all together. It is rather remarkable that in my long cross-examination I have never been attacked upon the general results of my analysis, the organic nitrogen going down as the organic carbon rises. And, moreover, there is another thing which has not been put to me in cross-examination which is very important. One statement I made, which I thought would have attracted Mr. Bidder's attention, was that one difference between sea water and sewage as regards its composition was the presence of ammonia, that the ratio of nitrogen to carbon is not very different, but that ammonia is absent almost entirely in sea water and present in sewage. Now ammonia is one of the elements of analysis which is to be taken into consideration; so that what I wish to make clear is that, although I admit (I do not think there would have been any truth in the results if it were not so) that taking any one single thing you may get great differences which may seem to upset the value of the analysis, it is only when you put the facts together that you can get an accurate opinion, and I say that, taking all the facts, from Teddington downwards, you have a singular concurrence of results.

10,644. Do you find any absolute law in the case of the water in any of the columns, or do you find anomalies?—I find anomalies, and I do not think that could be helped. Of course it would be much prettier to have a definite line, but that cannot be obtained. I can only say those elements are there, and if you ask me for an explanation I cannot give it.

10,645. Erith has more than the usual fluctuations?—I do not understand Erith at all; it is one of the difficulties in the river.

10,646. (*Dr. Stevenson.*) With regard to the ammonia, we all admit that the nitrogen of the sewage becomes converted into ammonia, but do you think any difficulty would arise from that?—It would evaporate or perhaps be oxidised.

10,647. You would regard the ammonia as an index of the amount of oxidation which the river, plus the sewage, has undergone; is that so?—No, I do not think I should. If I knew how much of the sewage was there at the starting point, and how much was afterwards absent, I could tell what oxidation had taken place. The difficulty I am bound to confess in the matter of ammonia is that when you bring a bottle home containing water I think the ammonia is far less probably than it was when it was put into the bottle.

10,648. Would it be oxidised, or what would have become of it?—Some of it would; therefore any details about the ammonia certainly will fall short of the actual facts.

10,649. (*Mr. Lumley Smith.*) You assume that there is far more ammonia in the water when it is taken out of the river that when it gets into the laboratory?—Yes.

10,650. And that is all in favour of the water?—Yes.

10,651. Now I will ask you another question. I believe you have been always strong upon the burning up theory. It is a well-known fact that in all the discussions with regard to water this has not been an absolutely admitted proposition, but is a matter upon which chemists have held different opinions?—Yes; and here I have opposed to me men of far greater experience and far more learning than myself.

10,652. (*Chairman.*) It is a contestable question in science?—Yes.

10,653. (*Mr. Lumley Smith.*) My learned friend talked about your last paragraph in one of your pamphlets as being a parting shot at Dr. Frankland. You and Dr. Frankland have generally been upon opposite sides?—Yes, upon this question. I do not wish to put my theory forward as absolutely proved, because Dr. Frankland holds different views upon the point.

10,654. Now a few words as to the extent to which the sewage is purified by contact with pure water. My learned friend suggested that the sewage of a million persons went into the water above Teddington Weir; that would be distributed over the district from Teddington to Lechlade, and so on——

(*Chairman.*) What was stated was that some years ago that was about the number.

(*Mr. Michael.*) Since that time great changes have occurred by the sewage being treated in many places and applied to the land.

10,655. (*Mr. Lumley Smith.*) That sewage is spread over 120 miles?—150 miles, I think, would be nearer the mark.

10,656. Occupying, I am told, 3,000 or 4,000 square miles. Now, would the effect of the sewage coming in from a village, and having the river to itself for seven or eight miles, be to purify it vastly more than if it were poured in in a vast mass at one spot?—Yes, certainly it would.

10,657. A few years ago did the sewage come in through drains? There were cesspools largely used in those days, were there not?—It came in anywhere.

10,658. Now a question has been asked about the River Irwell. It has been suggested to me that the water of the River Irwell, before it takes its final leap into the estuary, passes over a number of weirs; the number of nine was suggested to me?—Yes.

10,659. Would that have the effect of accelerating the oxidation process?—Yes; that will be one of the

questions I shall have to draw the attention of the Commission to when I deal with the question of the inch and a half of free oxygen. Taking the Shannon, where we get the Doonas Falls, and where we increase the oxygen from 1·2 to 2·1 cubic inches per gallon, I shall endeavour to show you the enormous alteration that takes place in the organic carbon consequent upon the increase of the free oxygen in the course of the Falls. One part of the evidence which I shall endeavour to lay before the Commission bearing upon that point will be that I shall take a section of the river where I get, say, 1·2 of free oxygen and show the organic carbon at different spots; then I shall take another point, where by means of the Doonas Falls I raise the quantity of the free oxygen and show the effect of that quantity of free oxygen upon the organic matter.

10,660. Now with regard to the sewage being burnt up, my learned friend asked you if half the sewage was not burnt up before it got to the outfall, and you said you did not believe it?—Certainly not.

10,661. Have you ever heard it suggested before?—No, I am quite sure nobody on the other side would suggest it.

10,662. Probably you are of opinion that when the water gets to Southend it is not a nuisance then?—I do not know Southend, but I should think not. As a matter of fact, sewage, or a mixture between sewage and sea-water, does form a very disagreeable mixture, a very offensive mixture indeed, owing to the reduction of the sulphates and, I think, to the setting free of sulphuretted hydrogen even in quantities which you cannot detect by the smell, because when you dilute sulphuretted hydrogen to a very great degree of dilution, so that you cannot even smell it, it still acts injuriously upon animal life.

10,663. When the sewage gets to Southend it has gone through what I may call the "horrors of the middle passage"?—Yes.

10,664. And the oxygenating process may be attended with nuisance from the purifying process; is that so?—I do not think oxidation can be attended with nuisance.

10,665. But during the progress up and down the river, when it was getting oxidised, the nuisance would arise?—The nuisance would arise, not from the oxidisation, but from the putrefaction.

10,666. Now one word with regard to some experiments which you were said to have made some time ago with regard to the free oxygen in the Thames water. Any slight matter, such as the bottles not being properly filled, and so on, would affect the result?—It would. Of course I quite admit that this question of free oxygen has only materially interested one in the last two and a half years, and I can imagine therefore such a number of things which would interfere with the accuracy of these results.

10,667. You were asked also a question about the quantity of suspended matter in sewage, and you have referred to a storm as to which Mr. Keates gave an analysis; have you referred to see the quantity of water which fell upon that occasion?—I think it was a quarter of an inch.

10,668. I think the only other question I have to ask you is this: Have you brought that which you promised to bring, viz., the analysis of the wells at Grays?—I cannot say that I have. I have the quantity of salt present in the Grays water which I can give to you as 13 grains.

Examined by the Commission.

10,669. (*Dr. de Chaumont.*) I was desirous to ask you some questions about the microscopic part of your examination. I wish to ask, with regard to the objects you found here, some of the reasons upon which you base the statements you make, especially with regard to the yellow amorphous matter which you seem to consider animal matter broken up an indication apparently of sewage; what was the exact ground upon which you made that statement?—I say that this deposit, which forms the most conspicuous microscopic feature of the samples of sewage mud and of a sewage water-deposit, is undoubtedly of animal organic origin. It always assumes a yellow tint (in fact, the precise tint seen in masses of disintegrated muscle), and is amorphous or faintly granular. It is entirely unlike the fine sharp angular fragments seen in unpolluted muds and deposits; these latter particles, under a high power, refracting light conspicuously, a circumstance that at once distinguishes them from the amorphous matter under consideration. The deposit precisely resembles the molecular matter that we have observed to result from the utter disintegration of *animal* tissue, more especially if kept under water. A great deal of that was the result of taking particles out of the dissecting room and keeping them under water for experiments. It was a very long series of experiments. In the case of disintegrating vegetable tissue its tendency is to break up into *fibrillæ*, more or less coarse, and not into the peculiar amorphous material described. It is exceptional, however, to find any traces of *fibrilla* amongst this particular deposit. It may be urged that isolated and young vegetable cells would exhibit no such breaking up into fibrils.

10,670. With regard to amorphous material of this description, have you never found, for instance, in a deposit of well-water, similar yellow matter which it would be almost impossible to say was sewage?—I do not think I have. I think I know the kind of deposit you are referring to; but if it were like that I should say it was animal.

10,671. I suppose you applied re-agents to it?—Yes; and I would say I tried staining materials with all these things, using hœmatoxylin chiefly for the purpose of bringing out the animal matter more completely.

10,672. (*Dr. Stevenson.*) You spoke of "yellow "amorphous matter," and "yellow matter"; you connect them both with muscular fibre, do you not?—Yes.

10,673. How do you connect the yellow amorphous material with muscular fibre, beyond what you have just said, you do not trace the intermediate changes, do you?—I do not. Some of these masses are very peculiar; some of them have definite outlines; in other cases the outlines are indistinct. Whether it means that that is passing into that stage I am unable to say. Here is a singular blending of those examples (*explaining the same upon the diagram*).

10,674. You attributed the colour somewhat to bile, I believe; have you at all tried to find out whether it contained iron?—I have not.

10,675. (*Dr. de Chaumont.*) You did not apply for instance hydro-chloric acid to them?—I cannot give you the result, but I have tried almost everything.

10,676. It was suggested to you in your examination that the deficiency of oxygen in the water was one of the causes of the death of the fish, but you did not in your answer mean to imply that the fish might not also have been poisoned directly by the water?—Certainly not, I do not know as a fact to what extent the oxygen must be deficient to prevent fish life; but I am equally certain, first, that there may be varieties of organic matter which may be themselves poisonous; and secondly, I am equally certain that the formation of sulphuretted hydrogen in the water owing to the action of the carbonic acid on the reduced sulphates would undoubtedly be poisonous to animal life. As a fact a very minute quantity of sulphuretted hydrogen put into the water of an aquarium will kill all the fish.

10,677. (*Dr. Stevenson.*) There is one question with regard to the oxygen I wish to have made clear,

*Dr. C. M. Tidy, M.A., M.B.*

28 Feb. 1883.

and that relates to questions 9957 and 9958. You mentioned that in one portion of the river there is a very large increase of organic impurity and that "the quantity of free oxygen is not very different "from that of the previous reach." Then you went on to say that "the water had been trying to keep "itself pure, it had had a struggle." Do you mean to say that when there is a certain quantity of sewage poured into the river, the oxygen ceases to be absorbed by the water; or is it absorbed and immediately destroyed by the sewage?—If I follow your question rightly, what I mean is when the oxygen is there, and the sewage is there, the sewage trying to pollute, and the oxygen to purify, that, for a long time the oxygen succeeds in keeping down the quantity of the sewage, but that there comes a time at last when the oxygen is incapable of keeping down the sewage.

10,678. In other words oxidation is going on very rapidly?—I mean that the sewage gets over and above the oxygen. There is an oxidation undoubtedly but that oxidation is very much less when you decrease the quantity of oxygen.

The witness withdrew.

*Mr. Michael* applied that Mr. Mansergh's plotted cross sections should be handed to the counsel for the Metropolitan Board of Works as had been previously, as he alleged, promised.

*Mr. Balfour-Browne* stated that he was instructed that the furnishing of these cross sections would put his clients to the expense of 1,000*l.*

*Mr. Lumley Smith* stated that he had not the slightest objection to the counsel for the Metropolitan Board of Works having access to them, but that what he objected to was to having do any work for the other side.

*Mr. Michael* stated that he did not wish at the moment to make copies, but merely to be permitted to to examine the sections.

*The Chairman* inquired whether Mr. Mansergh would have any objection to leaving them with the Secretary and letting them be examined.

*Mr. Lumley Smith* stated that Mr. Mansergh would leave them with the Secretary to the Commission for the inspection of the other side.

*Mr. Michael* stated that for the present he would content himself with his right to examine without asking for permission to make copies.

Dr. Edward Frankland, Ph.D., D.C.L., M.D., F.R.S., examined.

*Dr. E. Frankland, Ph.D., D.C.L., M.D., F.R.S.*

10,679. (*Mr. Lumley Smith.*) I believe you are Professor of Chemistry in the Normal School of Science and Royal School of Mines?—I am.

10,680. And Past-President of the Chemical Society and the Institute of Chemistry?—I am.

10,681. You were, I believe, one of Her Majesty's Commissioners appointed in 1868 to inquire into the pollution of rivers, and the best means of remedying it?—I was.

10,682. I think that was a matter which occupied your time for upwards of six years?—For about six years we were engaged upon the inquiry.

10,683. How long have you been acquainted with the water of the river Thames?—I have known the river Thames since the year 1845.

10,684. When you say that you have known it, you mean that you have not merely known it casually, but your attention has been directed to it?—Yes. In the year 1845 I used to cross it twice daily, and I have always taken notice of the condition of the river. I cannot say that so long ago as that I had any special object in noticing the sources of pollution of the river; but I noticed the extent of it.

10,685. It is a matter of common knowledge that, until the sewage was diverted from London the state of the river, as it passed through London, was bad?—It undoubtedly continued to diminish in purity until the time of the opening of the main drainage outfalls.

10,686. And since that time the condition of the Thames in London has improved?—The condition of the Thames in London has improved. After the opening of the outfalls the river markedly improved in purity; but since that time, from soon after the main drainage outfalls were opened, the purity of the river in London has been decreasing.

10,687. Did you make any inspections of the river in 1879?—Yes, I did, several.

10,688. How came you to make those inspections?—At the request of the Thames Conservancy I made several careful inspections of the river between West Moulsey and Erith.

10,689. Did those inspections make you acquainted with the state of the river for the whole of that distance?—Yes.

10,690. Beginning at the top, above Teddington Lock, where the water comes over Teddington Weir, in popular language, what do you find to be the state of the water?—Popularly speaking, the river is there a pure or unpolluted stream.

10,691. You have compared, have you not, the mud of the Thames there with that in other places?—Yes, we took a number of samples of mud, from the highest station to the lowest; we also took mud from the Mole, which is an important tributary of the river Thames. The latter contained only 2·63 per cent. of organic matter, and nearly the whole of that was of vegetable origin. We also took a sample at Hampton, as illustrating the mud of the unpolluted Thames; that contained 11·33 of organic matter, which consisted, to a great extent, of decaying leaves.

10,692. The mud of the upper Thames was chiefly vegetable?—Yes.

10,693. Then, when you got below Teddington lock, what did you begin to find?—The appearance of the river began rapidly to change for the worse; the water became muddy, and the mud became richer in organic matter, and that organic matter in the mud proved, upon investigaaion, to be more and more impregnated with animal matter as we went down the river. Opposite Deptford Creek the mud also exhibited an enormous number of red worms, known technically as blood worms, which I have always found to be characteristic of sewage matter in mud; they used to be very abundant about Hungerford Bridge. The mud there used to be quite red upon a fine sunny day, and if a stone were thrown into it the mud became instantly gray from the worms sinking below the surface.

10,694. Now, with regard to Hammersmith and Chelsea, have you anything to say with regard to the water there?—I have nothing to say, except, in general terms, that as we went lower down the river, the water became more and more polluted.

10,695. With regard to these blood worms, have you found them anywhere else, except off Deptford Creek?—Yes; we found them in the mud off Blackwall Point, at the dry dock there; and there also offensive gases began to rise to the surface, and the discharge of those gases increased as we neared the two Metropolitan outfalls at Crossness and Barking.

10,696. Dr. Tidy mentioned having been with you upon one occasion; do you remember that?—Dr. Tidy was there with me upon every occasion.

10,697. Do you remember what time of the tide it was when you were opposite Barking and Crossness?—When we were opposite Barking outfall it was dead low water, and, to my surprise, I saw at that time a very large volume of sewage being discharged into the river, because I had imagined previously that the sewage was only discharged during the first two hours or so of the ebb tide. I judged from the amount flowing out there that it would be between 20,000,000 and 30,000,000 gallons in the 24 hours.

10,698. And that, you say, was at dead low water?—Yes, that was at dead low water, just before the tide turned.

10,699. Was that offensive in any way?—Yes, there was a very offensive smell there.

10,700. Passing down the river, did you trace the effects of sewage in any way?—Yes, the effect was traceable down to Erith; the mud at Erith exhibiting decided evidence of animal matter in it.

10,701. Then you stopped at Erith, I believe?—Yes, we did not go further down.

10,702. That was in 1879—now, in last September, I believe you received some samples of water from Dr. Collingridge?—I had 20 samples of water that were forwarded to me by Dr. Collingridge.

10,703. They were all fully labelled?—Yes, they were all fully labelled, and they were labelled as having been collected upon the 14th of September. They were divided into two sections, as it were, one section of the samples being collected at high and low water respectively, and the other near the surface and near the bottom at the different stations.

10,704. At what stations?—The stations were Teddington, Chiswick, St. Paul's Pier, Deptford, and Barking.

10,705. I believe you analysed them, did you not?—I did.

10,706. And your analysis appear upon one of those tables. I think you may as well point out which it is. (*The tables and diagrams referred to in this evidence are those in Appendix A.G. put in by Dr. Tidy.*)

10,707. I believe you conducted your analysis independently of Dr. Tidy; he had other samples handed him?—Dr. Tidy had a similar set of samples for stations lower down the river.

10,708. Some were sent on the same date to Professor Way, and you have seen his results, I believe?—Yes, and also the results of Dr. Tidy's examination of the water at the lower stations.

10,709. Before we deal with this table, you also received some samples, did you not, upon the 26th of September which had been collected upon the 22nd?—Yes, I received them upon the 26th.

10,710. Those samples were taken at neap tide?—Yes.

10,711. And they were taken at Teddington, Chiswick, St. Paul's Pier, Deptford, and North Woolwich? Yes. The diagrams represent the result of the tables.

10,712. (*Dr. Stevenson.*) Is the "nitrates" in the last column nitrogen as nitrates?—Yes.

10,713. (*Mr. Lumley Smith.*) The table, No. 11, at the bottom, contains analyses of water taken upon the 14th of September at the five places you have mentioned from Teddington to Barking?—Yes.

10,714. The next table is a similar analysis for September the 22nd, but taking North Woolwich instead of Barking?—Yes; that is Table No. 12 at the bottom.

10,715. Now, with regard to the one which is numbered 13 at the bottom, what does that represent?—The third table of analytical results refers to samples taken at one station only, viz., at St. Paul's Pier, on different days, showing the condition of the river at that particular station on those days.

10,716. That represents, does it not, analysis taken every day from October the 28th to November the 11th, at St. Paul's Pier?—That is so. These are all the analytical tables. Then comes the diagrammatic representation of the first two tables.

10,717. Would you describe the first of the diagrams which you have handed in; first of all, what is it headed?—The first diagram is headed "Analysis of "water taken at mid-stream at different places on "September the 14th, 1882."

10,718. That is Table No. 11?—Yes.

10,719. Now, what is the next?—The second table is No. 12, "Analysis of water taken at mid-stream at "different places on September the 22nd 1882."

(*Chairman.*) Am I right in understanding that the Table No. 11 put in by Dr. Tidy was the result of his own independent analysis?

*Dr. Tidy* stated that that table was Dr. Frankland's.

10,720. (*Mr. Lumley Smith.*) The next, from Teddington to North Woolwich, September the 22nd, is yours?—It is.

10,721. Now the third?—The third is headed "Results of analysis expressed in parts per 100,000, "collected at St. Paul's Pier;" that is paged 16 at the bottom of the table.

10,722. Now what is the next?—Those are all the tables.

10,723. Now you have some diagrams, have you not?—Yes. The first diagram is called Diagram B.

10,724. What does that show?—That shows, in the upper half, the ratio of nitrogen to carbon in various samples collected at high and low water, at the places indicated upon the diagram on September the 14th, 1882. The second half of the same diagram, the lower half, represents the same thing in connexion with the second set of samples, those collected on September the 22nd, 1882.

10,725. Those are represented in curves from Teddington to Southend?—Yes; therefore they represent Dr. Tidy's samples as well as my own.

10,726. Your tables are based on your own analysis, but this diagram is based upon the combined tables and results of Dr. Tidy and yourself at different parts of the river?—Yes, that is so.

10,727. (*Dr. Stevenson.*) All your results throughout are expressed, not in grains per gallon, but in parts per 100,000?—I think that is so. In using the tables I have made some calculations in connexion with the inquiry in grains per gallon; but all the results in the tables now under consideration are in parts per 100,000.

10,728. (*Mr. Lumley Smith.*) I think you have also analysed the chlorine?—I have one diagram that would come before the chlorine. Diagram C. relates to the samples taken at St. Paul's Pier and at Erith upon the same days. The St. Paul's Pier samples were analysed by me, and the Erith samples by Dr. Tidy. The analyses made by me I have already handed in. These are two diagrams, representing the total carbon and nitrogen at St. Paul's Pier and Erith upon the same day, and the volume of water passing Teddington Weir upon the pays indicated. Now come the chlorine determinations. The chlorine determinations I have only put together recently, and they are not yet printed.

10,729. Now with regard to these tables, first of all are there any general observations which you want to make upon the river before we come to the details?—From the analytical results I have now been putting in, I draw the following conclusions, that in spring tides sea water makes its way up the river as far as Chiswick, but does not reach Teddington; and that wherever sea water is found there is evidence of the presence of sewage in the increased proportion of ammonia and of nitrogen in the dissolved organic matter.

10,730. Dr. Tidy attached a great deal of importance to the presence of ammonia as evidencing sewage; do you agree in that opinion?—Yes. I attach great importance to ammonia in that way; but unfortunately ammonia is a very evanescent substance which rapidly disappears from the samples after they are collected. When it is found it affords indubitable evidence of the presence of sewage, and of a certain amount of sewage; but there may have been a great deal more sewage there than is now apparent, on account of the ammonia having disappeared.

10,731. On its journey from the river to the laboratory?—Yes.

10,732. So that we may take the sewage results from ammonia as the minimum?—As the minimum.

10,733. Of ammonia there is very little or next to nothing in the Teddington water?—Very little indeed.

10,734. Is that also the case in sea water?—Yes, it is also the case in sea water; practically there is none in sea water.

10,735. Then if ammonia is found in the Thames, are there any sources from which it would come other than sewage?—There are no sources of importance;

*Dr. E. Frankland, Ph.D.,D.C.L., M.D., F.R.S.*

28 Feb. 1883.

there are certain discharges into the Thames which do contain ammonia; there is the Beckton Gas Works, for instance, but the amount from that source is, I should say, a vanishing quantity.

10,736. Now with regard to the nitrogen, you spoke of the increased proportion of ammonia and nitrogen; how does nitrogen give you information?—In those samples, from which sea water is practically excluded, the increase in the proportion of nitrogen to carbon indicates the presence of sewage matter; but that evidence cannot be trusted where sea water mixes with the polluted river water, because sea water contains organic matter which is highly nitrogenous, even more highly nitrogenous than that in sewage.

10,737. The nitrogen which you get in the water above the reach of the sea, would be evidence of sewage; but where you get down to the action of the sea water, it may be due to sea water?—Yes.

10,738. What is the next proposition that you lay down?—The character of the suspended organic matter varies very irregularly in different parts of the river; it is sometimes chiefly animal and sometimes chiefly vegetable, as indicated by the proportion of nitrogen to carbon contained in it. And in connexion with this irregularity it is worthy of note that a large proportion of the suspended matter in sewage is vegetable, although nearly the whole of the dissolved organic matter is animal, being the constituents of urine.

10,739. Is the dissolved organic matter a constituent of urine?—Yes, mainly; and it was shown in the Report of the Rivers Pollution Commission with respect to this dissolved organic matter, that it makes a stream much fouler by its discharge than is the case with the suspended matter.

10,740. Can you give us the reference to the evidence or the Report of the Rivers Pollution Commission?—It is the first Report of the Rivers Pollution Commission of 1868. I cannot at the moment give you the page.

10,741. May we take it as your opinion that the river is made more foul by the urine than in the fæces?—Yes, that has always been my opinion since I was a member of that Commission.

10,742. Although it is not so patent to the eye?—No, the eye very often deceives. People think that because water is clear and free from suspended matter it is therefore pure; that is by no means always the case. This is the Rivers Pollution Commission Report on Lancashire.

10,743. (*Chairman.*) Have you any other general results to state?—No.

10,744. You have now stated them. You were asked the question. what were the general results you drew.

(*Mr. Lumley Smith.*) There is yet another which is rather general, and we would rather leave that till we meet on the next occasion.

Adjourned to Tuesday next at half-past 12 o'clock.

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# TWENTY-SEVENTH DAY.

## Tuesday, 6th March 1883.

PRESENT:

SIR P. BENSON MAXWELL IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst. C.E.

WILLIAM POLE, Esq., F.R.S., *Secretary.*

DR. EDWARD FRANKLAND, called again and further examined.

6 March 1883.

10,745. (*Mr. Balfour Browne.*) I think upon the last occasion you promised to give the Commission the page in the Rivers Pollution Commission Report to which you had been referring?—I did; it is page 27 in the first report of Sir William Denison's Rivers Pollution Commission.

10,746. I think, in answer to my learned friend Mr. Lumley Smith, you had given the general conclusions at which you had arrived?—I had given some of them, but I was in the midst of them when the Commission adjourned.

10,747. First, I will ask you with regard to dissolved organic matter in ordinary river water, what have you to say with regard to that?—The dissolved organic matter in ordinary river water is non-putrescible, and contains an average proportion of nitrogen to carbon of 1 to 7, whilst the dissolved organic matter of sewage averages nitrogen to carbon equal to 1 to 2, in sea water the ratio is as 1 to $1\frac{3}{4}$; therefore in a mixture of sea and river water with sewage it is obviously impossible to tell from the ratio of the nitrogen to carbon alone, whether the highly nitrogenised organic matter is derived from sea water or from sewage. It is here that the importance of the ammonia determination comes in, and the ratio between the organic nitrogen and the ammonia, for in sea water the ratio of ammonia to organic nitrogen is only as 1 to 27, whilst in sewage the average is as 1 to 3,

10,748. But we have heard that ammonia is very evanescent; does that qualify what you have said with regard to the value of the ammonia test?—Yes, it qualifies it in one direction, as I think I mentioned upon the last occasion. Where you find this excess of ammonia, it is positive evidence of the presence of sewage; but, if you do not find ammonia, it is not positive evidence of the absence of sewage, the ammonia is evanescent, it rapidly disappears.

10,749. I suppose you have taken the presence of sea water as depending for proof upon the presence or absence of chlorine?—Yes; that is a proof of the presence or absence of sea water. But that there were many samples collected where there was little or no sea water in the river, is evidenced by the low proportion of chlorine in these samples.

10,750. Have you the analyses of any samples in which there was very little chlorine found, to lay before the Commission?—Yes, the tables are already before the Commission. At low water it will be found that at St. Paul's Pier, upon September the 14th, the ratio of the nitrogen to the carbon in the top sample was as 1 to 3·1, and in the bottom sample as 1 to 3·6.

10,751. (*Mr. Bidder.*) What table is that to which you are now referring?—That is the table numbered 11 at the bottom.

10,752. (*Mr. Balfour Browne.*) Have you upon the same table shown a similar result with regard to Deptford?—Yes; at Deptford upon the same day the

ratio was as 1 to 3·2 on the top and 1 to 4·9 in the sample taken 18 feet below the surface.

10,753. (*Sir John Coode.*) I see that in the low water samples there is a difference of a quarter of an hour between the periods at which they were taken, one is at 10 and the other is at 10.15, so that that is hardly a measure of the ratio, is it?—There would be a current at St. Paul's Pier, certainly, but I do not think that would affect the ratio much; of course as the samples were taken by one party, it was impossible to take them exactly at the same moment, but they might have been taken quicker, no doubt, than with 15 minutes intervals. The high water samples undoubtedly were taken at the same moment. Then with regard to those samples I would remark that the proportions of chlorine were only 4·06 in 100,000 parts at St. Paul's Pier, and 48·9 in 100,000 parts at Deptford, both being the proportions at low water.

10,754. (*Mr. Bidder.*) That is not upon the table, is it?—No, that is not upon the table, but that I have got from Professor Way's results, which are already in evidence.

10,755. (*Mr. Balfour Browne.*) Do I understand you to say that it is on account of the small proportion of chlorine that the ratio of nitrogen to carbon becomes of importance?—Yes, it does, because here there is no question of the admixture of sea water to any appreciable extent.

10,756. Now will you take low water at North Woolwich?—At low water at North Woolwich, upon September the 22nd, the proportion of nitrogen to carbon in the top sample was as 1 to 2·5, and in that sample taken 20 feet below the surface it was as 1 to 2·3, although the proportion of chlorine showed only a small admixture of sea water, namely, 8·3 per cent., which is practically nothing as affecting this ratio.

10,757. Have you given the chlorine upon these occasions?—I have said, at all events, that there was an admixture of sea water to the extent of 8·3 per cent., as indicated by the chlorine.

10,758. (*Dr. de Chaumont.*) In both samples?—Yes, they were both alike.

10,759. (*Mr. Balfour Browne.*) Did you apply the same standard to the samples taken at St. Paul's Pier from October 28th to November the 11th?—Yes, and these samples are very interesting, because they show what a very different condition of the river prevails at different times.

10,760. Which table are you now referring to?—I I believe it is on page 16. That gives the samples taken at St. Paul's Pier from October the 28th to November the 11th.

10,761. Do these analyses show that upon those occasions the river was almost absolutely free from sewage at that part?—They do; there was no appreciable evidence of sewage upon that occasion, that is to say, all the time from October the 28th to November the 11th that was the case.

10,762. Does the flow over Teddington Weir, to your mind, account for the analyses that you have upon that table?—Yes it does.

10,763. What was the flow then?—The gaugings show that 5,772,000,000 gallons passed on the average each day over the weir during that time. Now the average flow of the Thames is only 800,000,000 gallons, therefore the quantity of water passing down the Thames during that period was, on the average, seven times as great as the normal flow.

10,764. (*Dr. Stevenson.*) Is the ·046 as the quantity of ammonia, a misprint in the last column but one?—The figures ·046 are correct.

10,765. (*Mr. Balfour Browne.*) I think you have stated that the ammonia test is a good affirmative standard, but not trustworthy as a negative one?—That is my opinion of it.

10,766. Judged by that standard, can you say whether sewage was present in the river above the northern outfall, say, at Blackfriars Bridge on July the 11th, 1882?—Yes, I find, judged by that standard, undoubted evidence of sewage at Blackfriars Bridge upon that date, and also in a sample collected in a line with the Monument on June the 21st, 1882.

10,767. Are those upon the tables?—No, those are the results deduced from the tables; now I found it, as I say, in a line with the Monument upon the 21st of June; at Charlton, Ballast Wharf, Charlton Pier, at Woolwich, 200 yards below the entrance to the Royal Albert Dock, and a little below the Clock Tower, Beckton, upon June the 20th, 1882, again in a very large quantity at the last named station upon July the 11th; the proportion of ammonia in this sample, as will be seen from the table, being no less than 3·28 grains per gallon.

10,768. (*Sir John Coode.*) Is that in the table?—Yes, in the table of results, but not the deductions as to sewage. Those are my own deductions from the ammonia.

10,769. (*Mr. Bidder.*) I think you will find that the materials for the evidence that you are now giving are in Dr. Tidy's table, No. 11?—Yes, that is so.

*The witness explained to the Commission which tables were attributable to himself.*

(*Chairman.*) We may take it from Dr. Frankland that the pages numbered 11, 12, and 16 at the bottom are Dr. Frankland's own. The rest are Dr. Tidy's, with the single exception that some of the diagrams were drawn by Dr. Tidy, and in drawing them he had the assistance of Dr. Frankland.

10,770. (*Mr. Balfour Browne.*) You have spoken of the presence of sewage at various places at certain dates, and the last you mentioned was at the Clock Tower, Beckton, on June 20th, 1882?—Yes, that was about 550 yards above the northern sewer outfall, and upon the same side of the river.

10,771. Then you say again, I think, that at the same station, upon July 11th, the proportion of ammonia in this sample was very large?—Yes, I stated that it was 3·28 grains per gallon.

10,772. What is the proportion in unmixed London sewage?—It varies from 1·711 to 6·527 grains per gallon, and averages 3·013 grains per gallon.

10,773. So that upon this particular day you found a little more than the average in that sample?—Yes.

10,774. (*Chairman.*) Is that in a gallon?—Yes, of the water taken from the river, not from the sewers.

10,775. (*Mr. Balfour Browne.*) This is a sample taken from the river opposite the Clock Tower at Beckton. How far is the Clock Tower at Beckton above the northern outfall of the Metropolitan Board of Works?—About 550 yards.

10,776. Have you any opinion as to how or why that amount of ammonia came to be in that sample upon that particular day?—I imagine there was a stream of sewage flowing from the northern outfall and following the bank up the river at that time, so that the sewage with but a slight admixture of river water was on this occasion taken as a sample. That is my opinion about it.

10,777. Now at Chiswick, upon the 14th of September 1882, does your analysis show a very high proportion of ammonia?—Not a very high proportion, but an abnormally high proportion.

10,778. What table is that in?—The table of September the 14th is the first table I produced, that is to say, Table 10 on page 11.

10,779. Does that indicate to your mind any admixture of sewage?—Yes, it does, a slight admixture of sewage. Again, upon the same day, sewage was unmistakeably present at St. Paul's Pier.

10,780. That is shown upon the same table?—Yes, the table relating to Deptford and North Woolwich. North Woolwich is on Table 9, page 10.

10,781. That is upon the table for which Dr. Tidy is responsible?—Yes. Then upon the 22nd of September sewage in very appreciable amount was present in the Thames at Deptford and North Woolwich.

10,782. Those are upon your own two tables at pages 11 and 12?—Those are upon pages 12 and 13, page 12 being mine and page 13 Dr. Tidy's.

*Dr. E. Frankland.*

6 March 1883.

10,783. Is there not ammonia present in Teddington water?—Yes, but it is under 0·02 parts in 100,000.

10,784. Have you in all these analyses corrected for the Teddington proportion of ammonia?—I have. In the samples collected at North Woolwich on the 22nd of September the proportion of ammonia, after deducting that found at Teddington, was ·199 of a grain per gallon at one foot below the surface, and ·109 of a grain per gallon at 20 feet below the surface.

10,785. The first figure you gave was at one foot below the surface?—Yes.

10,786. North Woolwich is given on Table 11, page 12?—Yes.

10,787. You give as the average proportion of ammonia in London sewage 3·013 grains per gallon?—Yes.

10,788. (*Sir John Coode.*) That is taken from the sewer?—Yes, the average of 21 samples taken from a large London sewer. Then, taking the average quantity of ammonia in the London sewage as the basis of calculation, the numbers I have just given correspond to 6·61 gallons of sewage in each 100 gallons of Thames water at the surface, and 3·58 gallons of sewage in each 100 gallons of water 20 feet below the surface.

10,789. (*Mr. Bidder.*) Does that refer to the 22nd of September figure at North Woolwich?—Yes.

10,790. (*Mr. Balfour Browne.*) All these results ought in a sense, of course they cannot be corrected arithmetically, but they ought to be corrected practically by the fact that the ammonia is passing away, and that, therefore, these results are below the actual amount?—It is almost impossible to get the samples to the laboratory and analysed before a considerable proportion of the ammonia has disappeared.

10,791. Would you say that these amounts of sewage arrived at in the way you have stated indicate a serious pollution of the Thames?—Yes, I consider that these proportions of sewage are very serious indeed as being present at that portion of the river.

10,792. Upon August 16th you made, did you not, an analysis of water taken on that day?—That analysis was made by Dr. Tidy.

10,793. It was at All Hallow's Pier that the water was taken?—Yes, and there was an appreciable percentage of sewage upon that occasion.

10,794. That was made by Dr. Tidy, and it is on page 15, Table 13, I think?—Yes.

10,795. Again, from October the 28th to November the 11th, that is shown upon your table, page 16, during the period when the river was scoured out by a large quantity of water coming over Teddington Weir; what was the sewage at St. Paul's Pier on that occasion?—Practically nil, though there was abundant evidence of its presence at Erith.

10,796. It was present at Erith, but not at St. Paul's Pier?—Yes.

10,797. By the chlorine table, which I think Professor Way is responsible for, you found out the proportions of sea water at various points?—Yes.

10,798. You have used that table in your various calculations?—Yes, I have.

10,799. And those analyses of Professor Way's show that the sea water gets up the river as high as Chiswick?—Yes, there is evidence of a small quantity of sea water as high as Chiswick.

(*Chairman.*) We had this from Mr. Baldwin Latham.

10,800. (*Mr. Balfour Browne.*) Yes, the chlorine test has been used by every witness. (*To the witness.*) Does the presence of sea water, in connexion with the float experiments, afford evidence of sewage pollution at points very far above the outfalls of the Metropolitan Board of Works?—Certainly, because the sea water cannot obviously get up the river above the outfalls without carrying the sewage with it.

10,801. You are of opinion, are you not, that sea water contains upon the average 1,975·6 parts of chlorine in the 100,000?—I have made very numerous analyses of sea water collected upon our coasts and upon the Atlantic, and those are different in some respects from Dr. Tidy's which were given the other day. My figures come out on the average at 1975·6 parts of chlorine in 100,000 parts.

10,802. (*Sir John Coode.*) You say that you have taken samples from the Atlantic and from our own coasts, do you find any material difference between the two?—The sea water along our own coasts is always a little more dilute than it is in the middle of the Atlantic. The mid-Atlantic samples were not taken by myself; they were taken during the cruise of the "Porcupine."

10,803. We can dispense with them if you will give us those along our own coasts?—At Worthing I have found 1948·5.

10,804. (*Mr. Bidder.*) What are you reading from?—I am reading from the Sixth Report of the Rivers Pollution Commission, page 132. On another occasion I found 1995·6 also at Worthing; and, upon a third occasion, 1996·2; at Hastings I have found 2050; in mid-channel, between Arran and Ardrossan, if that is not too far out of the way, I found 1943·7; at Aberystwith, between the Ystwith and the Rheidol rivers, 1630, that is to say, that out at sea, between those two rivers, where it was, no doubt, diluted by the river water, it was 1630.

10,805. (*Sir John Coode.*) Were those all surface samples?—Yes; they were all surface samples, taken about a mile from the shore.

10,806. How do you account for the very striking difference between the 1948 at Worthing and the 2050 at Hastings; can you account for that?—No, except by the difference between the rainfall from time to time. For instance, such a rainfall as we had last month would make an appreciable difference. Then, in Mount's Bay, Penzance, I found 1987·5.

10,807. There we have no large rivers?—No. At Bridlington, from the end of the pier, January 11th, 1873, 1850 parts per 100,000; at Brighton, from the end of the new pier, on January 18th, 1873, I found 1962·5 parts; at Eastbourne, one mile from the shore, on February 22nd, 1873, the proportion was 1937·5; at Ramsgate, half a mile from the shore, on March 2nd, 1873, 1893·7 parts; at Portland, at the mouth of the harbour, on March the 11th, 1873, the proportion was 2012·5. Those are all samples upon our own coasts.

10,808. What is your general conclusion as to about the normal proportion in the sea in its normal condition at the mouth of the Thames; what would you give as your figure?—I would say it would vary, of course, when there is flood in the river, and when the river is very low; but I would say it would be at high water somewhere about 1900; that is merely a rough figure.

10,809. (*Mr. Balfour Browne.*) The 1975·6 is the average of all the cases you have been quoting to the Commission?—Yes; and also of the samples from the Atlantic; those are also included in the average.

10,810. (*Dr. Stevenson.*) May I ask, does not the chlorine in the sea water away from the shore always bear a definite relation to the total solid matter in the water?—I have not been able to verify that, but I should think it exceedingly likely. For instance, in the sample at Hastings, one hour before high water, the chlorine was rather high, 2050, and the total solid matter was also high, being 3955, whilst, when the chlorine was 1630 at Aberystwith, the total solids were only 3243, so that they obviously follow the same line of reduction and increase.

10,811. (*Mr. Balfour Browne.*) What number of parts of chlorine do you find in London sewage?—I find, in London sewage, a little over 10 parts in 100,000. The average is 10·3.

10,812. In Thames water you have already said what it is?—It is about ·2.

10,813. I think that Professor Way's analysis shows that the proportion of chlorine in all parts of the cross-section of the river is substantially the same?—Yes: and that is a very important thing to establish,

because it enables us, with much confidence, to calculate the proportion of sea water in the river; both at different depths and in different positions across the river it is the same.

10,814. That you have not done for yourself, but you have taken it from Professor Way's analysis?—I have.

10,815. (*Sir John Coode.*) Is that due to chemical affinity in any way, or, how do you account for the ready diffusion of the chlorine?—I think the mixture takes place partly by eddies in the river, and partly by diffusion; where you have two liquids of different specific gravity, there is always diffusion going on between them.

10,816. Do you think there is anything more than mechanical diffusion?—No, I do not think there is; I do not think there is any chemical affinity in the case.

10,817. (*Mr. Balfour Browne.*) You have made, have you not, some experiments which indicate the effect of the upland water in pushing back the sea water?—I have.

10,818. Will you give us those?—The results upon the tables which I have put in show how enormous is this influence of the floods during their continuance in pushing back the sea water. At North Woolwich during high water, for instance, one third of the river was sea water in September, whilst, on November the 30th, at high water, sea water to the extent of only one-fifteenth was present, the variation being from one-third to one-fifteenth.

10,819. Upon that occasion, when it was one-third, there was a small proportion of land water coming over, and when it was one-fifteenth there was a heavy flood?—Yes.

10,820. Have you determined the proportion of sea water in a large number of samples of water taken at various points upon the river?—I have.

10,821. From Teddington to Southend?—Yes.

10,822. These samples were collected upon the 30th of November?—Yes.

10,823. What was the result then?—The result then was that there was no sea water at Teddington, either at low or high water, and that the sea water at Chiswick was inappreciable, both at low and high water: and the same was the case at St. Paul's Pier. At Deptford the sea water was inappreciable at low water, but amounted to ·95 per cent. at high water; at North Woolwich it was inappreciable at low water, and 6·6 per cent. at high water; at Barking it was ·17 at low water, and 8 per cent. at high water; at Crossness it was 8·7 at low water, and 15·3 at high water; at Erith it was 4·3 at low water, and 17 per cent. at high water; at Southend it was 78·1 per cent. at low water, and 90·8 per cent. at high water. There was then a very heavy flood in the river.

10,824. It is upon these figures, as compared with other figures, that you have arrived at the general conclusions you have just stated to the Commission as to the effect of the upland water?—Yes.

10,825. (*Mr. Bidder.*) Let me ask you this question for the purpose of identification: those are deductions, are they not, from the tables already put in?—Those are deductions from Professor Way's tables.

(*Mr. Balfour Browne.*) They were put in by Mr. Baldwin Latham then for now.

(*Chairman.*) You are taking up a great deal of Dr. Frankland's time unnecessarily by making him give the contents of the tables.

(*Mr. Balfour Browne.*) But the witness has drawn the deductions from the tables.

(*Mr. Bidder.*) And those deductions have been given by the engineers.

10,826. (*Mr. Balfour Browne to the witness.*) I think you have given the deductions you have taken from Professor Way's tables?—The deductions are the percentages of sea water which I have calculated from the results of Professor Way's tables.

10,827. (*Chairman.*) Are the figures you have given us taken merely from Professor Way's tables, or, did you yourself analyse them?—I also made some of the analyses.

10,828. Those are your own analyses?—They are partly from my own analyses, and partly from Professor Way's; but the two sets of analyses agree very closely. There is, substantially, no difference between them.

10,829. They are the result of your own analyses then?—Yes.

10,830. (*Mr. Balfour Browne.*) In many cases you did your own analysis?—Yes.

10,831. From those experiments and from the float experiments, is it your view that during a heavy flood the sewage from the main drainage outfalls reaches London?—No, not during heavy floods; it is then carried bodily down.

10,832. But when it is discharged at or near low water, is it your opinion that when the river is low the sewage does reach London, and go above it?—When the flow of the river is normal, and below that, it then reaches London, and, under favourable circumstances, gets as far as Chiswick.

10,833. But, even under normal circumstances, how far would it get up; what part of London would it reach?—I would say it would get to Chelsea, certainly.

10,834. And, having reached there upon one tide, would it oscillate through London for a considerable number of tides?—Yes; I believe it would oscillate for many days, or even weeks, before it was finally carried out to sea.

10,835. Is it your view that the condition of the Thames in the metropolis, that is to say, from Chelsea to the Docks, is becoming worse or better?—I am of opinion that the river is rapidly becoming worse, partly from the greater amount of sewage discharged into it, owing to the increase of population in London, and partly from the accumulation of mud banks, which are increasing under our windows here, and are increasing from year to year; they putrefy in warm weather, and create what we may call a permanent nuisance.

10,836. Is it your view that it will become as bad ——

*Mr. Bidder* objected to the question.

10,837. (*Mr Balfour Browne.*) As bad as it was in the year 1858?—I think it is very likely it will before long.

10,838. (*Sir John Coode.*) Is it progressively worse?—In my opinion it is.

10,839. And not better and worse, according to the floods?—It is that; but I mean taking the average condition of it, it is gradually becoming worse.

10,840. (*Dr. Stevenson.*) Do you think it will become worse, if the amount of sewage thrown in does not increase?—Yes; I think it will even then become worse, on account of the accumulation of these mud-banks; I think they will go on increasing.

10,841. (*Mr. Balfour-Browne.*) When the Metropolitan Board of Works contemplated the present scheme for the disposal of the sewage, I think you were consulted with Dr. Hofmann, as to the deodorization of the sewage before it was turned into the river Thames?—Yes, that is so; that was in the year 1859. We had a great number of schemes of dealing with the sewage at Barking, and Crossness submitted to us at that time by the Metropolitan Board of Works, and we were requested to examine them, and to report which would be the best for the treatment of sewage, before it was discharged into the Thames.

10,842. So that at that time they appear to have contemplated deodorization. Did you report your view?—We did, and we recommended that deodorization should be carried out, especially in the summer, by means of per-chloride of iron.

*Mr. Bidder* objected to this evidence as irrelevant.

10,843. (*Mr. Balfour-Browne,*) However, you recommended deodorization, and that deodorization has not been carried out?—No, that deodorization has not been carried out.

10,844. Upon the last occasion, you mentioned a table, which you had made out, showing the amount

*Dr. E. Frankland.*

6 March 1883.

of suspended matter in London sewage?—I do not think I mentioned it upon the last occasion.

10,845. I think my learned friend, Mr. Lumley Smith, stated that it would be printed by our next meeting, and would then be put in?—That was so.

10,846. Have you that report before you?—I have.

10,847. Will you hand in a copy of it?—I will. (*The witness handed in a "Report on the suspended matter in London sewage." See Appendix AH.*) I may say that this is a very elaborate investigation into the amount of suspended matter discharged into the Thames from the London sewers in 1878 and 1879. I have taken out of the Registrar General's weekly returns the rainfall upon every day during those two years, and making use of all the sewage analyses which are available, many of them having been made by the late Mr. Keats, the chemist to the Metropolitan Board of Works, I have taken out the volume of sewage, and the percentages of suspended matter, and the total amounts of suspended matter discharged on each day during those two years. Then there is, at the end of this report, a summary, showing the aggregate quantity of mud discharged into the Thames during those two years; and this works out to 505,257½ tons of dry mud discharged in the year 1878; and in the year 1879, 541,965·8 tons. Then the quantity of wet mud containing 60 per cent. of water, which is the quantity of water determined, in the deposits in the Thames, by Dr. Tidy was 1,263,143·65 tons in 1878, and in the year 1879 it was 1,354,914·38 tons. Of course, if the Commission wish, I will go into the details as to the manner in which these numbers are arrived at, but they are all in this report, which, I presume, will be in the hands of the Commissioners.

10,848. Those are the results of your investigations, which you have just stated to the Commission. Now will you give us, first, the amount of dry mud, and, secondly, the amount of tons of wet mud?—Yes. Perhaps I may be allowed to say that I undertook this investigation, which was a very laborious one, from the conviction that little or no notice had been hitherto taken of the discharge of suspended matter during storms; it has been always, as a rule, fair weather sewage, or what Mr. Bidder calls normal sewage, which has been noticed, and I thought that it would be important to notice and ascertain what effect storms would have in increasing this quantity.

10,849. (*Professor Williamson.*) I wish to ask you what is your use of the term "wet mud." I presume it is collected without much drying, but it might be either very wet, or only a little wet; what is your unit?—60 per cent. of water was determined as the average, I think, of a good many samples of mud dredged up from these banks in the Thames near the sewer outfalls.

10,850. And taken as it came up in the dredger?—Yes.

10,851. Was it weighed in the state in which it was brought up?—When the water had run off it was weighed, and then dried; I take it as dry at the temperature of boiling water.

10,852. (*Chairman.*) It would vary, I suppose, according to the specific character of the mud?—Yes, a little; but I have given the dry mud, so that it can be taken in that way as well. These tables also show that when these enormous quantities of suspended matter are brought down by storms the proportion of mineral matter is very much increased, so that the mud is much less polluting than it is in fair weather.

10,853. (*Professor Williamson.*) Is it absolutely less?—No, not absolutely less, but relatively less; the absolute amount of mud is much greater.

10,854. It is not all organic mud, but some of it is inorganic?—It is a mixture of organic and inorganic mud.

10,855. What is the meaning of the tables on page 18 being ruled through with red ink, is it that they are not correct?—They are ruled through, first of all, because they indicate an abnormally large percentage of suspended matter, there is something abnormal about them.

10,856. (*Chairman.*) They ought rather to have been underlined, ought they not?—The object is to place the whole evidence before the Commission, therefore they are ruled through, they are eliminated, they are not intended to be taken as part of the average.

10,857. (*Sir John Coode.*) They are all exceptionally large, I see?—Yes, they are all exceptionally large; that is, therefore, in favour of the non-pollution of the Thames. I did not take these figures, lest it should be said that they were not taken fairly. Those marked with one asterisk are from the analyses of Messrs. Hofmann and Witt, which are published in the Blue Book; that is all explained in the report. You will see one reason for ruling out, upon April the 8th, "rain previous afternoon," which no doubt affected that sample, and that is ruled out as being abnormally high.

(*Sir John Coode to Mr. Balfour-Browne.*) I think it would be very desirable if you could give us, in future, these figures, all referring to one common standard, whether grains, or parts per 100,000, as far as you can.

*Mr. Balfour-Browne* stated that he would have that done in future.

10,858. (*Mr. Balfour-Browne to the witness.*) I see in this report that each table is described on page 2?—Yes.

10,859. Now I want to direct your attention to the question of oxidation. Dr. Tidy, when he was in the chair, I think, said that he had very often appeared upon a different side from yourself on this matter of oxidation, and getting rid of sewage by means of it.

10,860. (*Mr. Bidder.*) The point upon which they differed was rather the getting rid of the germs.

10,861. (*Mr. Balfour-Browne.*) Is sewage matter got rid of, in your opinion, slowly, or rapidly, by oxidation in running water?—It is got rid of very slowly.

10,862. You have, I think, made careful and repeated experiments upon the River Irwell?—Yes, I have on the River Irwell, just below Manchester, and before its debouchment into the Mersey, which takes place above Warrington.

10,863. I think you examined it from Throstle Nest Weir, which is just below Manchester, and below all the sewer outfalls and all the factories?—I took samples there, and again 11 miles lower down the river, just before it joins the Mersey, and compared those samples with each other; they were taken upon the same day, and time was allowed for the river to flow from one place to the other, as nearly as I could guess; of course, that was a guess.

10,864. (*Sir John Coode.*) What was the distance?—The distance was about 11 miles.

10,865. And the time?—I forget how much time we allowed for it; I think about 8 or 10 hours was allowed for the flow. I may say that the river, upon its way between those two points, falls over six weirs, a total height of 34½ feet; this fall covers the water with foam for hundreds of yards below each weir, so that it gets very well aërated at each of those weirs.

10,866. (*Mr. Balfour Browne.*) Each of those weirs affords a chance of good oxidation?—Yes.

10,867. What was the result of that 11 miles run?—The purification from suspended matter by subsidence was very considerable, varying from 9 per cent. of the total suspended matter up to as much as 48·6 per cent. deposited upon the road, but the purification from polluting organic matter in solution was much less, and was sometimes even a minus quantity, that is to say, there was no improvement whatever, but apparently, a deterioration, which was due apparently to precisely the same water not being taken in the two places.

10,868. Have you a short statement, which you can give, of your determinations?—I have. In the first determination there was a diminution in the polluting matter in solution of 1·7 per cent. in that flow; in the second determination there was an increase of 7·9 in the polluting matter in solution;

upon the third occasion (these were made upon three different days and at three different times of the year) there was a diminution of 26·6 per cent.

10,869. (*Sir John Coode.*) Are there any tributaries between the two points?—There are practically no tributaries between the two points. There are very few places in England so well fitted for such experiments. I know of only three, and I have made an experiment at each of those places, but this River Irwell more closely resembles the case of the Thames so I have selected it.

10,870. (*Professor Williamson.*) Was the temperature to any extent different between the dates of making those determinations?—It was. When the greater purification took place the temperature was higher.

10,871. (*Dr. Stevenson.*) Was the water examined for organisms?—No, there may have been organisms there, but there is no vegetation in this section of the river at all; it is too polluted for that.

10,872. Do you find that the power of self-purification of a river depends upon what are called micro-organisms in it?—Yes.

10,873. And does not a certain quantity of impurity prevent the existence of those organisms?—I do not know that. I think that what we may call the putrefactive bacteria get on pretty well in any sort of liquid.

10,874. You would not agree with the statement that the occurrence of these living organisms depends entirely upon the temperature of the medium?—No, I would not agree with that; upon the first occasion, that is, when the purification amounted to 1·7 per cent., the temperature was 6·2 Centigrade; when it amounted to 26·6 per cent., the temperature was 17·8 Centigrade.

10,875. (*Mr. Balfour Browne.*) Dr. Tidy compared the pollution of the Irwell below Manchester with the river flowing through Warrington?—Yes, and there he fell into a slight, or perhaps more than a slight, error, because the River Irwell does not flow through Warrington.

*Mr. Bidder* objected to the evidence on the ground that it was not usual to call one witness to rebut the evidence given by another upon the same side.

*The Chairman* ruled that the evidence was admissible.

(*Witness.*) I wished simply to explain the cause of the apparent discrepancy between Dr. Tidy's statement and my own; he says he examined the Irwell at Manchester, and again at Warrington; now, the Irwell falls into the Mersey 3 miles above Warrington.

10,876. (*Mr. Balfour Browne.*) Is the Mersey a much less polluted river than the Irwell?—Yes, much less.

10,877. Have you made experiments upon London sewage with the view of ascertaining, in the laboratory, the amount of oxidation that goes on?—Yes, I have mixed one volume of filtered London sewage with nine volumes of fresh water. I freely exposed the mixture to light and air, and then I syphoned the mixture over from one vessel to another every day, allowing it to fall in drops from one vessel to the other, so as to give it thorough aëration. I may say that it fell a distance of three feet from one vessel to the other. I found that after 96 hours the organic polluting matter of this mixture had only been reduced by 11·5 per cent.; and after 192 hours the reduction was only 27 per cent. That was the result of these experiments upon the mixture of London sewage with fresh water.

10,878. Does that result bear out your conclusion that oxidation takes place very slowly in running water?—Yes, it does. I assume that a river runs at not a less speed than an average of a mile an hour, and I say that the result of the experiment is that after 192 miles run such a mixture of sewage and water would not, from oxidation alone, at all events, have its impurity reduced by more than 27 per cent.

10,879. In the last answer you said that you did it with filtered London sewage?—Yes.

10,880. But that filtration, I presume, did not vitiate the experiment at all, because all the organic matter was in the sewage?—Yes, it was still polluted with the organic matter; but I filtered it, because the suspended matter would have introduced a difficulty into the analysis.

10,881. Did you also mix a certain proportion of urine with a quantity of deep chalk well water?—I mixed them in the proportion of one gallon of urine to 3,077 gallons of deep chalk well water; this mixture was exposed to the air, briskly agitated, and then syphoned over from one vessel to the other, as in the previous case. Samples were taken for analysis, from time to time, so as to ascertain what was going on; the mixture being first submitted to analysis before the oxidation began. The results of these analyses show that urine, when mixed even with enormous volumes of water, is under atmospheric influences very slowly oxidised. Flowing at the rate of only one mile an hour in a river, the mixture experimented on would travel over 264 miles before it would lose, by oxidation, seven per cent. of its polluting constituents.

10,882. Have you confirmed the result of these experiments by ascertaining the rate at which dissolved oxygen disappears in a mixture of the Grand Junction Company's Thames water and sewage?—Yes; I mixed the Grand Junction Company's water with five per cent. of fresh London sewage, and immediately after the mixture the proportions of organic carbon, organic nitrogen, and dissolved oxygen, and also dissolved carbonic acid, were carefully determined. Then the mixture was put into a number of carefully stoppered bottles which were exactly filled with it, so that no air could gain admission. One of those was opened every day, and the amount of dissolved oxygen and of carbonic acid was determined every 24 hours, except upon the occasion of an intervening Sunday, when 48 hours elapsed between two determinations.

10,883. (*Sir John Coode.*) For how many days?—That was carried on for six days.

10,884. (*Mr. Balfour Browne.*) Are those figures that you are going to give upon the supposition that the oxygen disappeared every day by being used up by the organic matter of the sewage?—Yes, I am going to assume that all the oxygen that had then disappeared was used up in oxidising it, and converting it into carbonic acid, water, and free nitrogen—that is entirely upon an assumption which I am going to tell you cannot be the case here; but, assuming the oxygen was doing its work in the way of burning up the sewage, as has been mentioned before, then in the first period of 24 hours 6·8 per cent. of the sewage would be destroyed, and in the second period of 24 hours 8·9 per cent. of sewage would be destroyed.

10,885. (*Sir John Coode.*) Do you mean in addition?—Yes, in addition. Then in the third period of 48 hours, that was the one with the Sunday intervening, 14·3 per cent. would be destroyed.

10,886. Also in addition?—Yes, all these figures are additional. Then in the fourth period of 24 hours 5·4 per cent. would have been destroyed; in the fifth period of 24 hours 5·8 per cent. would have been destroyed; and in the sixth period of 24 hours 2·1 per cent. would have been destroyed.

10,887. (*Dr. Stevenson.*) Could you give the Commission the amount of oxygen which disappeared in the first 24 hours?—Yes, you have it all in the sixth Report of the Rivers Pollution Commission, page 138; in the first 24 hours ·803 was the weight of oxygen which was left after 24 hours, so that what had disappeared was the difference between ·946 and ·803.

10,888. That is about 15 per cent.?—I presume it would be. I am not very rapid at mental arithmetic. The other weights are all given at page 138 of the sixth Report of Sir William Denison's Rivers Pollution Commission.

10,889. (*Mr. Balfour Browne.*) You said that you

*Dr. E. Frankland.*

6 March 1883.

would explain further as to the oxygen not being entirely used in the destruction of sewage, will you now do so?—Yes; these numbers I have been giving are upon the assumption that the oxygen was doing its work simply in the way of destroying the sewage; but, as a matter of fact, there was no sewage whatever destroyed during this time, because, if the sewage had been so burnt up, then the proportion of carbonic acid found in those bottles would have increased, whereas it remained exactly the same during the whole time; so that no sewage whatever was burnt up during the time; it was only oxidised into more highly oxygenous compounds.

10,890. So that in one sense that ·803 destruction of sewage gives quite an erroneous notion of what took place?—Yes, it is merely adopting that assumption which, as I have said, is quite an absurd assumption under the circumstances.

10,891. You have given us the results of the examination of the river Irwell at various points of its flow, and found out the rate at which sewage disappeared in that river, and then you have performed the experiment with a mixture of sewage and urine, and you have found out that the rate of disappearance is exceedingly slow in those cases?—I have; and I say that it is impossible for us, taking those experiments as our guide, to say how far water so contaminated must flow before the sewage has become oxidised and converted into inorganic compounds.

10,892. Is that the case even when the sewage is mixed with large volumes of pure water?—Yes.

10,893. I see that upon this diagram A., which was put in by Dr. Tidy, two red lines have been drawn by you, will you explain them?—They show the same things relative to samples taken by himself and taken by myself. The samples were not taken under the same conditions of time, therefore I thought it worth while to draw out the curves showing the result of my own analysis, and they are as represented by these red lines; they tell the same story, but in a somewhat milder form. The river was presumably rather more in flood at this time; it was later in the season when my samples were taken.

10,894. What date was that?—These lines refer to the dates of September the 14th and September the 22nd.

10,895. Those lines represent the mean, I think, between aboslute high water and absolute low water?—They do. Each index point in these curves is the average of four analyses; two of the samples were taken at high water near the top and near the bottom, and two at low water near the top and near the bottom; one line represents spring tides, and the other neap tides, the upper line being the spring tide line.

10,896. And by putting on these lines, does that in your opinion confirm the accuracy of the results of Dr. Tidy's table?—It does; we have the same rise in them of organic impurity, at the same places they rise in the same way, but not so high.

10,897. (*Sir John Coode.*) Is not there rather a discrepancy between the red and black lines upon the top left-hand side of the table. There is a general agreement until you get near the end, and then there appears to be a falling off in your red line?—I think that is probably owing to the much larger number of samples which were examined by Dr. Tidy. This line falls from that line to there (*pointing to the diagram*), because there was no sample analysed between those two points; my red line represent only my own samples. There is an interesting thing here with regard to the organic nitrogen which shows that the organic nitrogen and the organic carbon almost meet at Southend, owing to the increased organic nitrogen in the sea water.

10,898. (*Dr. Stevenson.*) Have you any experiments in support of the conclusion that putrescible matter oxidising in water will eventually give rise to bodies containing as large a per-centage of nitrogen as carbon?—No, I have no experiment showing that.

(*Mr. Balfour Browne.*) If you draw a line from 47 to the bottom of 58, you will find that the two lines are exactly identical.

(*Sir John Coode.*) That bears out what Dr. Frankland told us, that, if he had had intermediate observations, his line would have corresponded with Dr. Tidy's line.

(*Mr. Bidder.*) In point of fact, the red line after a certain point is hypothetical altogether.

10,899. (*Mr. Balfour Browne to the witness.*) Now I will ask you one general question. You have spoken of the oxidation that takes place in the flow of the river; would oxidation take place more rapidly in a tidal river, such as at Barking and Crossness, than in a river which was non-tidal, flowing over stones and weirs?—Upon that point I can only give you my opinion gathered from my general study and experience. I have no definite observations upon the subject, but I should say that oxidation would be likely to take place more slowly in such a tidal river as the Thames than in a non-tidal river.

10,900. (*Professor Williamson.*) Have you any experience of the effect of the presence of salt upon the process of oxidation when sewage is present, whether it increases or diminishes the rate of it?—I have no experience in that respect.

Cross-examined by Mr. BIDDER.

10,901. You say very frankly that you have no definite observation which would enable you to say with confidence that the process of oxidation does go on more slowly in a tidal than in a non-tidal river?—No, I have no experimental determinations upon which to form a trustworthy judgment.

10,902. With regard to the figure you gave to the Commission in support of your opinion that oxidation goes on more slowly even in a non-tidal river than Dr. Tidy thought, I shall not be wrong if I say that you and Dr. Tidy have come to a diametrically opposite conclusion upon that point?—Upon the point of absolute quickness and slowness we are opposed, but we do not differ fundamentally upon the fact.

10,903. Dr. Tidy says that, if you put sewage into an unpolluted river, a run of 14 miles will destroy it, but your evidence goes to show that 20 times that run will not destroy it?—Yes.

10,904. Your evidence being founded upon the tables which are given in the Rivers Pollution Commission Report?—Yes.

10,905. Now I will ask you this: Is it quite certain that the laboratory experiment of water kept in a bottle and syphoned off to another bottle is quite the same as water running in a tidal river over a rocky or sandy bottom?—As far as oxidation is concerned, it is quite the same, I think.

10,906. You are aware, I presume, of the experiments made by Dr. Tidy, in which the results are very different?—I think I explained them.

10,907. You mean that they were not what Dr. Tidy thought they were?—I think he was mistaken in the conclusions he drew from the experiment. That is what I said upon the last occasion. You are referring, I think, to the experiments upon the River Shannon?

10,908. No, I am not. I am referring to the experiment recorded at the end of his pamphlet, conducted by himself, by mixing certain proportions of sewage and river water, letting it run a certain distance along troughs, and analysing it before and after the experiment?—Yes; those are laboratory experiments.

10,909. I will take one for illustration from page 44 of his pamphlet. "River water contained 4 per cent. "of sewage; the time and travel occupied a distance "of 1 mile in 8 hours; result, that of the oxygen "required to oxidise the organic matter before the "experiment, 2·80 of a grain, 1·9, or more than "2/3rds, had disappeared in the process." Does

not that experiment show, if such a result is obtained, that 2/3rds of the organic matter had disappeared in the course of that experiment?—Yes, if the experimental results are altogether conclusive upon that point; but that did not appear to me at the time to be so. I really forget now the objection I raised to those experiments at the time, but it is recorded, I think, in that same journal.

10,910. (*Chairman.*) You differed from that?—Yes.

10,911. (*Mr. Bidder.*) Have you performed that experiment of Dr. Tidy's yourself, and got out a different result?—No, I never performed the experiment which you have described.

10,912. Then how do you mean you differed?—I differed as regards drawing a conclusion from the experiment; and, if I am not mistaken, I think the ground for my demurring to that experiment as conclusive was this: That, first of all, these troughs were out in the London atmosphere, where they were exposed to all kinds of dust and dirt; secondly, that in the gutters of these troughs (because they were V-shaped, if I remember rightly) the suspended matter underwent some sort of putrefaction, at all events it formed the nidus for bacterial life and organisms of that sort, which, no doubt, are very active in destroying sewage matters.

(*Sir John Coode.*) Is that rate of progress right, one mile in eight hours; it seems incredibly slow?

(*Mr. Bidder.*) I believe it is right.

10,913. (*Chairman.*) You mentioned a quantity of sewage matter getting into a V-shaped trough, and so generating bacterial life?—That would induce putrefaction of the sewage, and my experience of sewage and sewage-contaminated water is that such matters purify much more rapidly by putrefaction than by oxidation. They are much more offensive while they are putrefying, but they purify more quickly by putrefaction than by oxidation.

10,914. (*Sir John Coode.*) When you say they are more offensive, do you mean that the gases they would give off would be more injurious?—Yes.

10,915. Not simply more offensive, but actually more injurious?—Yes, because the gases are mixed with sulphuretted hydrogen usually during putrefaction.

10,916. (*Mr. Bidder.*) If I follow you, you no doubt accept Dr. Tidy's observation of what resulted, but your explanation of it is that possibly there was London dirt got in, and possibly there was a development of bacterial life?—Yes. There is another point which now occurs to me; if I had known that I should be asked these questions, I would have looked through the papers; that probably the diminution in the organic matter which Dr. Tidy found upon that occasion was due to the decomposition of urea in the fermenting matter which was deposited in the V-shaped gutters.

10,917. We have a hypothetical matter fermenting which has developed in the eight hours of the experiment?—But the experiment lasted much longer than eight hours, I think.

10,918. Perhaps you know better, but all his experiments, he says, were of the duration of about eight hours, from 3 p.m. till 11.30 p.m.?—I was under the impression that his experiments were continued the next day.

10,919. Will you see for yourself (*handing the pamphlet to the witness*)?—You are right.

10,920. So that the time is rather short for the fermentation and development of bacterial life?—A good deal may be done in eight hours in the way of propagating bacteria.

10,921. We have not only got to develop them, but we have got to get their action upon the sewage. Now that leads me to ask you another question. Is it not the case that in a river, where sewage is mixed with large quantities of river water, there is a great development of living organisms which play a very important part in dealing with the sewage elements?—Yes, I should say that is very probable, although I am not personally familiar with the subject.

10,922. Have you made any observations with a view of ascertaining to what extent the living agencies in the case of a river like the Thames operate?—I have made observations in the unpolluted portions of the Thames itself, where all these things which you are speaking of, I presume, would be in activity, such as plant life, and so on.

10,923. Just let me ask you this: when you as a chemist analyse a sample which somebody has brought to you from a part of the Thames, you ascertain what is organic by distinguishing between the combustible and non-combustible portions, do you not?—Oh dear, no. I burn the residue of the sample, and determine the weight of the carbon and of the nitrogen in the organic matter.

10,924. Perhaps I put my question clumsily; your chemical analysis does not distinguish between dead and living organic matter?—No.

10,925. So that, in point of fact, what you are recording in your analyses as organic pollution may be, as far as your chemical analysis goes, your organic scavengers?—Yes, as far as the chemical analysis goes; but I have made a microscopic analysis at the same time. I have examined many samples of Thames water which have been perfectly clear, and have never been able to discover one of these scavengers. When there is a deposit of suspended matter, then, as a rule, you find these organisms in this suspended matter. But surely, if they were present in such large quantities, you would find them in the clear water.

10,926. Let us go step by step, if you please; as far as a chemist is concerned, he has no means of telling from his analysis whether that which he records as organic nitrogen and carbon represents dead polluting matter, or such as I called living organic scavengers?—No.

10,927. Have you made microscopic examinations of the water in that part of the river which we are considering, to determine what the facts are?—No; that part of the inquiry was left entirely to Dr. Tidy and Dr. Beale, I think.

10,928. Dr. Tidy has confined himself, I think I may say, in his microscopic examinations, entirely to mud?—Yes, I think that is so.

10,929. With regard to your opinions as to the slowness of oxidation, as stated in those figures which you have given us, which you took, you say, from laboratory experiments, you yourself have just referred to certain actual observations in polluted rivers which you have recorded in the Rivers Pollution Commission Report?—Yes. I have given you the result of one on the Irwell.

10,930. Do they not contain observations which show by the flow of the river a destruction of organic matter quite as great as anything that Dr. Tidy suggested?—No, I think certainly not.

10,931. I will ask you to look at the report; but first I will come to your evidence about the Irwell. In one case you found that after a certain number of miles there was an increase of pollution?—Yes.

10,932. Is there the slightest doubt that that was caused by the interposition of polluted matter between the two points?—Certainly it was not, because I have examined every yard of the run between the two points.

10,933. Do you mean to say it is your opinion, as a scientific man, that the river in a certain number of miles of its flow was increased in pollution?—I did not say that. I said that probably the water which was examined after a certain number of hours was not the same water as passed over Throstle Nest Weir at the commencement of the flow; but I say that I have observed constantly, even in the laboratory, an increase in the soluble polluting matter in a water, and I have attributed it in those cases to the solution of a portion of the suspended matter in the water, and that is also probably the case in this instance.

10,934. (*Professor Williamson.*) The insoluble

*Dr. E. Frankland.*

6 March 1883.

becoming dissolved up?—Yes; that is a thing that will sometimes occur.

10,935. (*Mr. Bidder.*) Now, I will draw your attention to one of your own recorded observations upon the River Irwell. I do not know what the distance between Throstlenest and the Mersey is?—Eleven miles.

10,936. I see you record upon the 11th of June in a certain year that the organic carbon at the head of that reach was 2·134, which, at the time of reaching the Mersey, was reduced to 1·35?—That was the occasion upon which the great reduction took place.

10,937. That was about 32 per cent.; from 30 to 31 per cent.?—Probably it was. I will take your figures.

10,938. The remarkable fact, I see, according to you, is that, whilst that was taking place, the organic nitrogen had actually increased?—Yes; but to a very unimportant extent, that is to say, within the error of experiment, I should say; it is ·002 practically; the organic nitrogen, you may say, remained practically the same.

10,939. What had become of the organic carbon; did it vanish in the form of carbonic acid gas?—That would be the conclusion that would be drawn if there were no other possibility.

10,940. Is not that the right conclusion?—I doubt it.

10,941. What is the alternative?—Still, I am not prepared to say it might not have occurred upon this occasion, because the river was then in a state of putrefaction; and, as I have said, when putrefaction goes on rapidly, and generates marsh gas, that would carry away the carbon, but not the nitrogen.

10,942. I also notice that you also give the Darwen as coming under your observation; what length of river is given in this experiment?—Thirteen miles.

10,943. The organic carbon which, at the beginning, was 2·127, was, at the end of it, 1·89; and the nitrogen, from ·295, has fallen to ·141; so that, if these figures are correct, from some source or other there had been a loss of 50 per cent. in a flow of 13 miles?—Yes; and the explanation of that is that the volume of the river is doubled by the reception of unpolluted water between the two points.

10,944. But is that so?—As far as we could gauge the river between the two points, that was so; you have it in the report.

10,945. But having it in the report does not make it the fact, you know; we have long got beyond that?—There is no doubt that the river was very largely increased. I followed it down all the way for the 13 miles on foot.

10,946. (*Professor Williamson.*) Did you take occasion to examine the composition of the water that flowed in, so as to ascertain whether it was pure?—I did not examine every stream which came in, but I examined the Ribble, which is an unpolluted river running very nearly side by side with this, and took the composition of the water coming in, as being the same as that of the River Ribble, which was very much purer than the water of the Darwen.

10,947. (*Mr. Bidder.*) How are we to reconcile your evidence as to the number of hours and miles of flow which would be sufficient to destroy pollution, with the facts which Dr. Tidy has given us, that the River Thames above Teddington (at any rate a few years ago, if not so now), after receiving the sewage of a million of inhabitants, was drinkable water at all times?—I do not think it is at all times a drinkable water.

10,948. Still, it was so near drinkable, that it is the subject of a difference of opinion between you and Dr. Tidy whether it is or not?—Yes, that is so.

10,949. That being all the difference of opinion, the statement is one which, for quoting purposes, might very fairly be taken?—I would explain it in this way, that there are, between those two points, Lechlade and Hampton, where the water companies take the water supply, a great many affluents coming in, more especially the Wey, which comes in immediately above this point, and is a considerably purer stream than the Thames; there is also an immense quantity of chalk water in the shape of chalk springs coming in at Reading, rising up in the bed of the Thames; then there is, above Hampton, a state of things very favourable to the purification of the river, namely, an enormous filtration of the river through the gravel there; it sinks into the gravel, and comes out again below the next look; indeed, at the present moment, the Lambeth Water Company is drawing a quantity of its supply from this gravel water.

10,950. (*Sir John Coode.*) Can it be seen distinctly passing through the gravel?—It cannot be seen; at least, I have not seen it, except in the Lambeth Company's works which they have intentionally sunk down into the gravel. So rapid is the supply now, that they get nearly the whole of their supply from that source, and I have proved, from analysis, that the water is very much purer than the Thames water which is flowing immediately above that part of the river.

10,951. (*Mr. Bidder.*) Therefore you argue that it is Thames water, because the analysis shows that is different?—It is Thames water, no doubt.

10,952. Do you seriously suggest that any considerable body of river water flowing down the River Thames, takes a dive into the gravel, and, after passing through the gravel, comes up again into the body of the river?—Yes, I do.

10,953. Although it has an open channel to run in?—Yes; it can be clearly shown that it does.

10,954. (*Sir John Coode.*) What you think is, that the weir creates a head which drives it below the gravel?—Yes, that is what I mean.

10,955. (*Mr. Bidder.*) I believe each individual weir makes a head of about seven feet?—Yes, I believe so; but there are many weirs. I have not the slightest doubt about the possibility of its being as I say.

10,956. Still, your affluents have not got rid of the sewage. Now, I will draw your attention to this, that when you have all your affluents in the river, the entire gauging of the Thames, affluents and all, is only between seven and eight times the quantity of the London sewage; and, inasmuch as you had, at the time that Dr. Tidy speaks of, the sewage of a million people, which is equal to a quarter of the London sewage, you would have contamination in the upper river in the proportion of 1 to 28?—But one million people do not drain directly into the Thames.

(*Dr. Stevenson.*) But, in relation to that, may I interpose by asking, are there a million of people draining now into the Thames?

(*Mr. Bidder.*) Not now.

(*Dr. Stevenson.*) I think the number was stated in a paper which was recently issued at 600,000?

(*Witness.*) That was so stated in the year 1874.

10,957. (*Dr. Stevenson.*) You say that the waters of the Wey are purer than those of the Thames?—They are purer in flood time; but, in perfectly dry weather, there is not much difference between them.

10,958. (*Sir John Coode.*) Have you put before us all the points you wish? I am afraid you were rather interrupted in the explanation you were giving us?—I think I have stated the main points as regards the purity, namely, the influence of springs in the bed of the river; the influence of comparatively unpolluted affluents which, however, is the least important of the three conditions, and especially the flow of a large volume of the river water through gravel above Hampton. That, as I have shown repeatedly, is a very powerful purifying process; a passage through five feet of gravel is worth more than a flow of 100 miles in a river.

10,959. Would not that gravel, in process of time, become polluted itself?—No, there is a true process of oxidation going on there, and even when raw sewage is used under intermittent filtration, there seems to be no blocking up of the gravel, the organic matter is really burnt up.

10,960. (*Mr. Bidder.*) Have you any experiment to show that any part of the water which flows down

the River Thames does pass through gravel in that way?—I have seen it in the gravel.

10,961. But that is not the same thing, because you have seen water in the gravel, that may have been either water in the stratification, or water which had percolated in from the Thames, but that does not show that it goes back to the Thames?—If water is flowing over a bed of gravel, and a weir dams it up, and there is communication between each side of the weir, it is almost a matter of necessity that a large quantity of water must pass through the gravel.

10,962. I ask you the question, have you any observation whatever to show that any appreciable quantity of the water in the river does perform that operation?—I have seen an enormous volume of water pumped out from by the side of the Thames, and this water I have shown to be identical with the Thames water, as regards the inorganic constituents; and, inasmuch as that water was immediately below a weir, I cannot doubt that it passed from the upper side of the weir and the lock to lower down the river.

10,963. Conceded that if you put a well down in a gravel stratification in the neighbourhood of the Thames, you can get enormous quantities of water out of it, and that that water is coming out of the Thames, flowing out from the bottom of the Thames, and being lifted by pumps; yet I ask you have you any observation to make as to the passage of any considerable portion of water, first, into the gravel, and then by nature, without any pumping, if you can help it, back again into the river?—I have no actual observation of it, but it must be so.

10,964. (*Chairman.*) Upon the principle of water finding its level?—Yes, upon the principle of water finding its level, it will pass easily through coarse gravel.

(*Sir John Coode.*) I think, discuss it as you may, it is a question of the surrounding conditions, it may, and it may not be so.

(*Mr. Bidder.*) I am sure Sir John will agree with me, that it is not a question in which you can say must be; I am not denying that there is any portion, but I am doubting whether there is any appreciable quantity that passes in that way.

10,965. (*Dr. de Chaumont.*) You said, just now, that the passage of water through gravel caused a diminution in the organic matter of the water, and you considered that to be a case of pure oxidation?—I do, because I find that even when gravel has been used, for the filtration of sewage for five or six years there is no more organic matter in it at the end of that time than there was at the beginning.

10,966. Is not that due to the operation of the bacteria?—That opens up the whole question of the functions of bacteria. I think that oxidation is, at all events, helped by the action of bacteria.

10,967. You did not mean to say that it was entirely due to oxygenation?—No, I meant it was due to the organisms in the gravel, as well.

10,968. (*Sir John Coode.*) Can you point out any case in which the gravel has remained the same after five years' use?—Yes, there is the case of the Beddington gravel. I analysed the gravel after it had been used at the Beddington sewage farm for five or six years. I also analysed some gravel at the same place, through which the sewage had not passed, and found the proportion of organic matter almost exactly the same in the two samples.

10,969. Have you any other case that you could mention?—Yes, there is the case of laboratory experiments, in which sewage had been continuously filtered, through five feet of gravel, for several months; and upon analysis, the gravel did not show anything more than a very small increase, if there was any at all, in the amount of organic matter.

10,970. (*Professor Williamson.*) I presume that was sewage containing suspended matter, and not clear sewage?—No, the suspended matter was taken out, by a little apparatus, in my laboratory experiments.

10,971. Therefore, the sewage did not contain suspended matter?—In the Beddington sewage farm, of course it did.

10,972. (*Mr. Bidder.*) When you refer to the instance of the sewage farm, is not the process of filtration by gravel, upon a sewage farm, what is known as intermittent downward filtration?—Yes.

10,973. That is very different from what takes place in the bed of the river, you cannot have intermittent downward filtration there?—Yes, I think you would, from the varying level of the river.

10,974. (*Sir John Coode.*) And, moreover, you would not have the vegetable growth in the river that you would in the Beddington Farm?—My experience has been mostly upon farms where there had been a crop grown; but I have investigated an intermittent filter, on which no crop was grown.

10,975. Are you right in that?—Yes, in the first year on the Methyr Tydfil intermittent filters there was no vegetation, but after the first year they planted cabbages.

10,976. (*Mr. Bidder.*) As I understand, you send a certain quantity in upon the filter, and then stop, and the consequence is, that the air passes over the ground; then you again pass over fresh sewage, and again stop, so that you are constantly reoxygenating the gravel, and preparing it for another dose of sewage; but that cannot go on under the bed of the river?—No, but still there is no doubt that the filtration through the gravel does oxygenate the water to a very large extent; we see it also in the case of surface wells.

10,977. Now you state also that the condition of the Thames is becoming worse, and I must ask you a question upon that?—I did say so.

10,978. What is your evidence of it?—There are banks of mud, which are found in various places, and especially in the higher parts of the river.

10,979. I want you to be very precise about this. I want you to say what proof you have, in support of that opinion, that the condition of the river is becoming worse; you say, first, the banks?—Yes, the banks; under the very windows of the Houses of Parliament there is a mud bank, which contains a good deal of sewage. Then I go by the appearance of the river.

10.980. With regard to the banks of mud, you made a considerable number of observations in the river Thames, for the purpose of the last inquiry into mud banks, in the year 1878–79, I think?—At the close of 1879, and they extended into 1880.

10,981. But your observations were made in 1878, were they not?—They were made towards the end of 1879, I think.

10,982. And you had an opportunity of examining the river again last year, had you not?—I have had no opportunity of examining the river, except one.

10,983. You have had a great many samples of water to analyse?—Yes.

10,984. And of mud too?—No, Dr. Tidy did all those.

10,985. You had the opportunity of studying them?—Yes, but I have not studied them.

10,986. Can you give any observations at all, comparing 1879 with 1882, to show that the river is in a worse condition now, than it was then?—No; when I made that statement I meant from observation of the appearance of the river, and from the quality of the mud dredged up in various places in 1879.

10,987. Forgive me for pointing out that one observation will not show progress?—No, one observation will not.

10,988. We must have two at any rate; now, what is the evidence of progressive impurity?—I say from the appearance of the river, it is progressing in impurity. I have seen after the opening of the main outfalls large quantities of fæces floating up with the tide past the pier at Westminster Bridge.

10,989. You have seen that, you say, since the outfalls commenced?—Yes, since the outfalls commenced.

*Dr. E. Frankland.*

6 March 1883.

10,990. Where those matters came from you do not know?—No.

10,991. Were they in large quantities?—Yes they were very numerous.

10,992. (*Sir John Coode.*) More than could have come from vessels and barges upon the river?—Yes.

10,993. (*Mr. Bidder.*) When was that?—That would be about the year 1873, I think.

10,994. Again I ask, where is the evidence of progressive impurity?—I never saw that before, and I saw it then, that is progressive evidence.

10,995. Pardon me, in the first place it is ten years ago, and further, if it is evidence of anything, it is only evidence of the fact that the condition of things is different from what it was before the outfalls were opened; does your observation enable you to say, that the condition of London, between the bridges, is worse than it was before the outfalls were opened?—I have never said that.

10,996. I beg your pardon?—I never said anything of the kind.

10,997. You said you saw these things floating about in 1873, and you never saw them before?—I meant I never saw them before, since the outfalls were opened. I had seen them before that.

10,998. Besides that eye observation 10 years ago, and remembering that you have been employed scientifically in 1879 and 1882, have you one single observation to point to that suggestion of progressive impurity?—Yes, I have noticed the condition of the mud more especially below the outfalls. About the year 1860, I used to yacht a good deal upon the Thames about Erith and that district, and certainly at that time the mud on the banks of the river was in a much less foul condition, than it is now, or was three or four years ago, when we inspected it for the Thames Conservancy.

10,999. You are now speaking not of this part of the river here, but of below the outfall, and you say its condition, according to your recollection when you used to yacht in the river in 1860 (as a young man, I presume), is different from what it was when you observed it in 1879 scientifically?—Yes, that is so.

11,000. I presume I am not wrong in saying you were a young man in 1860?—I was old enough to know what mud was.

11,001. Do you see much of the river now?—I cross the river four times a day as a general rule.

11,002. (*Chairman.*) Your opinion is based as I understand, not upon any laboratory experiment, but on your personal observation as one of us, I might say?—That is so.

11,003. (*Mr. Bidder.*) What part of the river do you see every day?—I see it as I cross between Charing Cross and Cannon Street.

11,004. Is that part of the river getting worse?—Yes, I think so.

11,005. This is from observations taken from a railway carriage crossing a railway bridge?—Those are daily observations, but you know I have had many opportunities, from making special trips upon the Thames, of observing what its condition is.

11,006. But you have been specially engaged for some months past for the purpose of proving the pollution of the river?—Not upon the river.

10,007. But scientifically?—Yes, in making analyses.

11,008. And you have nothing to bring forward?—I think I have brought forward a good deal.

11,009. I will just deal with the points upon which, if I followed the facts, you relied, as charging us with polluting the lower part of the river upon certain occasions. I gather that you rely more upon the ammonia, than upon the relation of nitrogen to carbon?—I rely upon the ammonia entirely where the river is mixed with a large quantity of sea water.

11,010. You have given up the ratio of nitrogen to carbon, where there is a large quantity of sea water?—Yes.

11,011. It is interesting to observe the disintegration of creeds, you did believe in the ratio of nitrogen to organic matter?—Yes.

11,012. And you did upon the last occasion, believe in the ratio of the nitrogen to carbon in the sea water?—Yes, but there is no mud in sea water; the mud of the sea water, if there is any mud at all, is practically free from organic matter.

11,013. You gave us certain occasions, for instance, the 11th of July and the 21st of June were the dates you gave me?—Yes, those were the dates upon which Dr. Tidy's samples were taken.

11,014. Those were the dates you referred to as indicating a large quantity of ammonia, one I think you said you could only account for by saying that the sewage was running up in a sort of eddy along the bank in the neighbourhood of Beckton?—July the 11th and June the 21st were the two dates I gave and the localities were at Blackfriars Bridge in a line with the Monument at Charlton Ballast wharf, at Charlton Pier at Woolwich, at 200 yards below the entrance of the Royal Albert Dock, and at a little below the Clock Tower at Beckton.

11,015. I understood you to say, and I followed you as carefully as I could, that you found below the Clock Tower at Beckton, that there was a quantity of ammonia which exceeded the average in sewage, and that what that indicated to your judgment was that there was a flow of sewage running up from Barking?—From the northern outfall.

11,016. Have you taken so little trouble in examining these observations as not to know that that was not a sample of the outfalls sewers at all, but a sample of the Beckton Gas Works sewage, and is so shown by Dr. Tidy in his observations; look at No. 44 on Table 1: "Sewage from Beckton, July the 11th, ammonia 3·28;" that is labelled by Dr. Tidy and properly labelled "Sewage from Beckton?"—Then that is a mistake of mine, undoubtedly, but I was not bringing any particular indictment against you in that case.

(*Chairman.*) There is no question here of indictment against anybody, it is a question of fact, that we have to enquire into.

11,017. (*Mr. Bidder.*) That had nothing whatever to do with the river, that is perfectly clear?—No, I do not know where I got hold of it. It might be that the numbers in some instances had been transposed, perhaps.

11,018. Then that observation, you will agree, falls to the ground?—Yes, and therefore I have no necessity to explain how such a thing could happen. I confess it rather puzzled me.

11,019. It shows what a chemist can do in the way of hypothesis when necessary?—It was not a very violent hypothesis after all.

11,020. Now I will ask you another question, you have put in a large paper or "Report" as it is called, which purports to deduce certain results from the amount of matter which came from the sewers in the year?—Yes.

11,021. I must ask you some questions upon it. Table A. is simply a record of the rainfall and the weather observations?—Yes, that is the official record published by the Register General.

11,022. That carries me on to page 18, where I find Table B. I notice in the first place that in getting your average you have mixed up observations from the old days before the Metropolitan Outfalls were made at all, of particular sewers in London, with recent observations of the Metropolitan Board of Works Sewers; in point of fact the first page is almost exclusively, with one or two exceptions of old sewers that we have nothing to do with?—I have availed myself of all the observations upon the composition of London sewage that I could find. As far as the storm samples were concerned, I was driven to take the results obtained (and which are published in an official form) by Professor Hofmann and Mr. Witt.

11,023. I have very little to ask you about Table B. because I see you bring out as the result the average of what I will call normal sewage?—And below, even, your own average.

11,024. I do not complain of that. I make it 24 and a fraction, and you make it 23·36 grains?—Yes.

11,025. Now I pass on to page 21, where I suppose what you intend to do in section 2, is to get the average of the discharged matter when the rainfall is between ·01 and ·30, and apply it to all the cases in the year in which there was that rainfall observed?—Yes.

11,026. That is your mode?—Yes, that is my mode.

11,027. Again, I beg to observe these are mixed up observations, ancient and modern?—Yes, unfortunately modern observations are so very few upon the sewage with any rainfall at all.

11,028. (*Chairman.*) I understand you to have struck out the observations in 1857 and 1869?—Yes, I have struck out the first two observations in 1857 and 1869 and the first observation made any use of, is April the 7th 1869; that is the only one before 1878.

11,029. (*Mr. Bidder.*) You have done something even worse or more inaccurate here; you have struck out all the low results, and so got a high average?—Yes; but you did not complain about my striking out the high ones in the former table.

11,030. That is a very smart remark, but I would point out this. I did not ask you to strike out the high ones before; I suppose you had your own reasons for doing it?

11,031. (*Chairman.*) Why did you strike out the low ones in this table?—I struck them out because they are obviously abnormal, they are much lower than fair weather sewage. If all the cancelled numbers were retained in striking the averages, the final result, as regards the quantity of mud annually discharged into the Thames, would not be very different. Thus in 1878 it would be 434,573·2 tons of dry mud instead of 505,041·8 tons; and in 1879 it would work out to 461,808·9 tons instead of 541,765·5 tons. The average amount of suspended matter per gallon of dry weather sewage would be 25·60 grains instead of 23·23 grains. With a rainfall not exceeding ·03 inch, it would be 31·18 grains instead of 42·91 grains. When the rain exceeded ·03 inch, but fell short of 1 inch, the average would be 60·09 grains instead of 90·02 grains; and when the rainfall was 1 inch and upwards it would be 116·42 grains instead of 134·94 grains.

11,032. (*Mr. Bidder.*) But does it follow that they are obviously abnormal?—I think so.

11,033. Are you not aware that this has been given in evidence over and over again by gentlemen who have observed the sewers, that if you have a rainfall after a long drought, you have at first a very heavy discharge of suspended matter, but that if the rainfall is followed by successive falls of rain, you will have very little discharge of suspended matter in the after days?—If you say there are many such data, I should like to know where they are. I know of only one determination.

11,034. If there has been a long drought, and then comes a smart fall of rain, the matter which has been collected in the sewers, is swept down the sewers, is it not?—Yes.

11,035. And carried out into the Thames?—Yes, but not so suddenly as you suppose; it will go on for a couple of days, I imagine.

11,036. If you have several days of rain, the first day's rain will give you a very large discharge, because it will give you the accumulation of weeks; the other cannot give you anything like so high a rate of suspended matter discharged, because the first heavy rain would have cleared out the accumulations?—The average suspended matter would be high, even for a week, I should say.

11,037. Have you any observation to show that?—Yes, there is one in the first table which will show what I mean, and that is why I have struck it out. On April the 8th, 1857, at page 18, there was no rain that day, but there had been some upon the previous afternoon, and the sewage flowing from the King's Scholars Pond sewer, which was one of the largest sewers, draining the whole of Belgravia, contained no less than 41·1 grains per gallon of suspended matter. Now that, as you will admit, is abnormally high, and it was very properly struck out, but that was from the rain of the previous day.

11,038. Now, I will draw your attention to another thing. I think you heard the evidence of Sir Joseph Bazalgette in the last case, and you are aware that since the year 1869, a system of catch-pits, frequently cleared, has been introduced throughout London, for the express purpose of preventing the road matter from getting in any quantity into the sewers?—Yes, and I do not believe they answer their purpose efficiently.

11,039. Again, I ask, have you any evidence or observation to confirm that statement?—Yes, I have made numerous observations as to the effect of such catch-pits, not merely in London, but in many towns in the United Kingdom, more especially in the provincial towns.

11,040. Confining ourselves to London, have you any observations which justify you in making the assertion that the efforts of the Metropolitan Board of Works in introducing catch-pits into London have been perfectly futile?—I did not say they had been perfectly futile.

11,041. You said they were not efficient?—I said they had not been efficient.

11,042. You mean to say that they have been partially futile?—They do collect a certain portion of the mud, but a very small part.

11,043. In this second section in your report, on page 21, from 1879, you have only four observations?—Yes.

11,044. And three out of the four you have rejected?—I have rejected them.

11,045. I can hardly grasp why, in trying to get the average, you have rejected the last three cases, they were facts; in those cases you have the rainfall coming down?—But they were exceedingly minute in the last case; in the first, ·01 inch, it was "thin rain, afternoon and evening." Now, thin rain to that extent only, as a rule, has very little effect upon the sewage; it is absorbed by the dust in the street, and does not get into the drains at all.

11,046. (*Sir John Coode.*) When you say it has very little effect upon the sewage, you mean to say that its power to carry matters into the sewers is very slight?—You will see that that is all misty rain that has been rejected.

11,047. (*Mr. Bidder.*) But the ·03 is the very maximum rainfall of this section?—Yes, "with fog and thin rain till afternoon; cloudless," and so on "afterwards."

11,048. Will you let me draw your attention to this, that when the same descriptions give you a big result, you do not reject them; "foggy in morning, overcast with occasional misty rain" on October 22nd, 1879, produced you 32·82?—I have tried to be as fair as possible in the construction of the averages, and, I think, you will allow that I have been very good to you in the first table.

11,049. I do not think so. I think you have made a little concession there in order to get a gigantic advantage here. Now we proceed to section 3, "rainfall above ·03 and under ·1," here again there are only two observations before the year 1871?—I anticipated that you would not accept that without an objection; those were the only two samples of sewage ever examined with that rainfall.

11,050. Section 3 has only two observations altogether, and they are both, as I say, before the year 1870?—Yes.

11,051. And they neither of them relate to the metropolitan outfalls at all?—I am very sorry I cannot give you better evidence; but you have not got it either. Those are the only two available samples which have been taken.

11,052. As a matter of fact, these averages have been drawn from two observations only which have been taken, and you reject one of them?—It is not

*Dr. E. Frankland*

6 March 1883.

an average, and I think it is not fair to put it in that way.

11,053. Then you really present a table based upon such facts as that as having any reliable result?—At all events, it is the best that can be had.

11,054. A table based upon an observation from two sewers 14 or 15 years ago, before the present system was introduced, taking the high figure and rejecting the lower one, do you seriously present that to the Commission?—The table was one of a long series of results obtained in the laboratory, and the samples were all taken from that one, Northumberland Street Sewer; and though I am very sorry that that is the only sample I can submit to the Commission, I think the number, as far as it goes is trustworthy, and moreover you see it comes very fairly between the two other tables, that is to say, between the average of 42·9 in section two, and the average of 134·94 in section four.

11,055. Now we come to section four from ·1 of an inch up to anything above it?—Yes.

11,056. I see here again only two observations of the outfalls?—That is entirely the fault of the Metropolitan Board of Works.

11,057. It is our fault that you have not got any more observations; now there is some limit to what we can bear, but why is it our fault?—I ought not to say "fault," but really there were many opportunities which might have been used for determining what was the composition of the London sewage in stormy weather. As a matter of fact, I am very sorry to say it, because the chemist who might have taken these samples and given us the result is now no more, and cannot defend himself; but still, as a matter of fact, these samples which were taken at the northern and southern outfalls are always suspended when there is a heavy rainfall; they stop, and then they begin again when there is finer weather. I do not mean to say that that was done of purpose, but still there is the fact.

11,058. Do you say that the late Mr. Keates carefully suspended his samples during flood?—I do not suggest that. I merely give the fact that when there is a heavy rainfall there are no samples taken and no analysis made.

11,059. Were not those very samples taken by Mr. Keates?—Which samples do you refer to?

11,060. Those samples which you used in 1879?—No, they were my own. I took them myself.

11,061. Did you take those samples upon the 30th and 31st of December 1879?—I did not take them myself, but they were taken for myself and Dr. Tidy by an officer of the Thames Conservancy, and Mr. Keates took some at the same time.

11,062. And gave evidence?—Yes, those are the only examples of storm sewage which were taken in the whole series.

11,063. Now as all the Honourable Members of the Commission have not the book, I will read the figures: "1879, December 30th, ·21 of an inch. "Thunderstorm between 1 and 1.30 p.m. Frequent "heavy showers. Sample taken at northern outfall "at 3.25 p.m., showing 119·4 grains of suspended "matter per gallon, of which 77·4 are mineral, and "41·98 organic." Then I will read the next entry, which refers to the very next day, the 31st December, with an almost identical rainfall: "Rainfall, ·19. "Weather, frequent rain. Observation taken at "northern outfall at 3.15 p.m.," almost at the same time of day. There instead of 118 grains of suspended matter you only find 29·69?—Yes, that is so.

11,064. Is not that the strongest possible corroboration of what I was suggesting to you just now (this is a violent thunderstorm between 1 and 2), that the first violent storm swept the great amount of accumulated matter from the sewer, and then afterwards, however heavy the rain may be, you get very little?—You will observe that the thunderstorm occurred between 1 and 1.30, and that sample was taken at the northern outfall at 3.25 p.m., now there would not have been time for the great mass of the stuff which was brought down by that storm to reach the outfall.

11,065. But by the next day there would be 24 hours interval?—Yes.

11,066. Have you any doubt that the reason of the small quantity brought down by the same rainfall the next day, was that the first violent flow swept the accumulated mass out of the sewer?—I have very considerable doubt as to that being the case. I think the "frequent rain" of the following day being distributed over a much greater length of time, would leave a good deal of the detritus stored up in the sewers comparatively untouched. No doubt the thunderstorm upon the 30th would sweep out a good deal of the material, but I very much doubt whether the ·19, if it had fallen in thunder showers as it did upon the 31st of December, instead of falling at intervals, would not have given a different result from this which appears. Moreover, it is rather difficult to get a fair amount of suspended matter in a sample collected at the northern outfall. I have collected a number of samples there, and a great deal depends upon the way in which you use pail for the sample, whether you get the due proportion of suspended matter there.

11,067. (*Sir John Coode.*) When you say at the northern outfall, where do you mean exactly?—In the sewer just before it empties into the reservoir.

10,068. (*Mr. Bidder.*) Now I would draw your attention to a further statement or assumption of which you have no proof. This was an observation taken two hours after a thunderstorm, and you have assumed, have you not, that that quantity of suspended matter which was observed at that particular moment was pervading the whole of the 24 hours?—Yes, I have assumed that.

11,069. That is pure assumption, is it not?—Yes.

11,070. You have no evidence of that as a fact?—I have no evidence of that as a fact beyond this sample, any more than I have any evidence of the low quantities continuing during the 24 hours.

11,071. You say you have no evidence that this continued for the 24 hours; but do you observe on the other hand, that upon the face of your own table you have the evidence that in 24 hours it had fallen from 119 grains to 29?—Yes.

11,072. Is it a reasonable assumption that during all that 24 hours it was coming down at the higher ratio?—It may have been double this quantity at some time during the 24 hours.

11,073. You have no particle of evidence of that?—No; but inasmuch as the main body of the sewage could not possibly have reached the outfall at that time, it is possible that the 119 grains may have been greatly exceeded at some later time.

11,074. That is a pure assumption, is it not?—No doubt.

11,075. You assume that that proportion of suspended matter lasted the whole 24 hours, although the thunderstorm only begins at the thirteenth hour? I have taken the quantity of water which fell upon the 120 square miles of London, or whatever the area is, to the depth of ·2 of an inch.

11,076. You assumed that every gallon of water which fell upon the area of London when ·2 of an inch of rain fell carried that proportion of suspended matter with it?—Which is a very probable assumption.

11,077. Having got an observation at the northern outfall just two hours after the storm came on, which was sweeping the solid matters out of the sewers into the river, you assumed that that was coming out the whole of the 24 hours of the day?—Yes.

(*Sir John Coode.*) What I understand Dr. Frankland to say is, that there may have been periods in the 24 hours when the quantity flowing out might have been very much larger.

11,078. (*Mr. Bidder.*) No doubt; but still I am dealing with the assumption. (*To the witness.*) Now do you know that that particular thunderstorm followed a long period of dry frosty weather?—Yes, that was so.

11,079. Now, when I come to look at your application of these averages, I find that you have actually put down the 31st of December on which you found 29 grains to the gallon, and treated it as if it had been 134?—I have used the average number that I have got in section 4 for the average amount of rainfall.

11,080. Against the fact that the effect of your rainfall that day is only 29 grains to the gallon, you have carried it into the average of 134?—Yes.

11,081. Between four and five times as much as you know from observation was brought down?—That observation was taken at a time far distant from this thunderstorm, and, although there was a fall of rain of ·19 during that day, I do not believe that that amount of suspended matter represents the normal condition of sewage under that rainfall, because it is exceeded so very frequently in dry weather; it is enormously exceeded in dry weather.

11,082. As far as the main outfalls are concerned, you have only two observations, and you do there as you have done before, reject the one that was small, and take the one that was big?—Yes.

11,083. That is your notion of taking an average?—But there are a number of other corresponding observations in the tables, so you cannot object to it.

11,084. Now passing from that, Table C gives us the working out and the application of these averages for the two years 1878 and 1879?—Yes.

11,085. Then, passing to page 24, I will take the one day on which 2½ inches of rain fell. I suppose that the 3,676,000,000 gallons represents the total quantity of rain that fell upon that day?—Plus the water supply.

11,086. Have you allowed nothing for evaporation?—Yes, I have, 20 per cent. I know that, if it were in the country, 20 per cent. would not be sufficient, but the evaporation in London I conceive to be very small, as the water runs directly from the roofs and roads and streets into the sewers.

11,087. I do not know whether you are aware that the 3,676,000,000 gallons is about seven times as much as can possibly go through the outfalls of the Metropolitan Board of Works when they are running chock full?—I do not mean to say that all this came from the mouths of the northern and southern outfalls. A great deal of it would come from the storm outfalls, which would be all running very heavily during that flow.

11,088. But, pardon me, it cannot even get through the storm outfalls without flowing through the sewers. Are you aware that those quantities that you have represented are more than all the sewers in London can carry?—But do you represent that upon this day 2½ inches of rain did not fall?

11,089. I do not at all?—Then where did it go?

11,090. That is not my business to show?—Possibly it did not all go down the sewers to the river.

11,091. Now I will ask you, are you aware that this quantity far exceeds the united capacity of all the London sewers?—I am not aware, indeed, of that, and I should be surprised to find that it was so; but there had been such things as sewers bursting from overcharge during rain.

11,092. Did the sewers burst upon any of these occasions?—I do not know that they did.

11,093. Now Table D. is a development of the tables arrived at in the way that we have indicated?—Yes.

11,094. And is as much entitled to credibility as they are, and no more?—Just so.

11,095. That will do for these tables. Now let me ask you about some other matters. You have spoken a good deal about sewage working its way up the river, I suppose it is not more likely to work up the river than it is to work down?—No, it works a little more down than it works up, and in time of flood, as I have stated, it works down the river altogether.

11,096. You have spoken about the progressive impurity of the river, and I will draw your attention to this. You said that at Teddington the ammonia which you now take as your chief guide was 0·02 parts in 100,000?—I said it never exceeded or it was below 0·02 parts, but the exact number is given in the analytical table of Professor Way's results.

11,097. I want to draw your attention to your Table 10 on page 11 and Table 11 on page 12?—Those are mine.

11,098. At Teddington (and, I suppose, it is fair to take low water, because then it is not contaminated by any of the sources of contamination below) you show the ammonia to be ·012?—Yes, that is on September 22nd.

11,099. Now turn to the next table, which relates to the very same day, but to a lower part of the river?—Those are Dr. Tidy's tables.

11,100. We will take low water at Southend, because it has then its least connexion with the sea. ·01 at each low water?—That is so.

11,101. That is rather purer than at Teddington?—There is rather less ammonia, but that is not very wonderful.

11,102. Then, so far as ammonia is an indication of pollution, the water at Southend on September 22nd was rather better than at Teddington?—Yes; and I should have been much surprised if it were not so.

11,103. At low water, you know, at Teddington, the water is water which has come from 8 or 10 or 12 miles higher up the river?—Yes.

11,104. And the water at Southend is practically sea water?—Yes.

11,105. But, whatever it contains, the fact is distinct, and it is a fact that the condition of the water is better at Southend than at Teddington?—The condition of the water as regards ammonia.

11,106. (*Chairman.*) The amount of ammonia is about the same, is it not?—Yes, the amount of ammonia is about the same.

11,107. (*Mr. Bidder.*) Between those two points you have the whole mass of the London sewage, and all the accumulations, if you are pleased to say that there are accumulations?—Yes.

11,108. And the tendency, as you admit, is, on the whole, down the river?—Yes.

11,109. Now, how is the progressive impurity consistent with the fact that the water at Southend is as pure as it is at Teddington?—It is perfectly consistent, because it is mixed at Southend with an enormous quantity of sea water.

11,110. But I think your own figures show us that the water at Southend has about 25 per cent. of river water?—Not upon that day.

11,111. Not upon that day; I am thinking of another day?—It was, 90 per cent. of it, sea water, I think, upon this day.

11,112. Mr. Mansergh's tables showed 27 per cent. of fresh or river water at Southend upon one day?—The sea water at low water at Southend was 92·6 per cent. of the whole upon the 22nd of September, so that, as it was nearly all sea water, you could not expect much ammonia there.

11,113. Let us go a little above Southend; let us go to Gravesend; at Gravesend you show still better for ammonia?—At low water it is ·06.

11,114. I beg your pardon; one is ·06, and the other, at the surface, has no ammonia at all?—No; but as I have explained, it is no use going on with the ammonia at all, because it is only a positive quantity.

11,115. It only shows what is against us, and does not show anything for us: "Heads, I win; tails, you lose." You say the presence of ammonia indicates sewage, and when it is not there you say it does not indicate that there is not sewage present?—The chemists will understand what I say as to the presence of ammonia; it is nothing to me whether it is in your favour or against you. What I am saying is, that it is a well known fact that ammonia in water very soon disappears.

11,116. How can that be a true indication of sewage which is an accident; which may be absent while sewage is present, or may be absent because the sewage is absent; it may be present because sewage

*Dr. E. Frankland.*

6 March 1883.

is present, or, it may be present for other reasons?—If it is present it shows that there is sewage in the water.

11,117. If it is not present, still, possibly, the sewage is there?—Yes.

11,118. And there is no other way of indicating sewage except by the presence of ammonia?—There is no other way which is feasible in the Thames at Southend and Gravesend.

11,119. What condition is the sewage in when the ammonia has vanished?—The polluting organic matter of the sewage may still all be there.

11,120. What is the test of the presence of polluting organic matter when the ammonia record is pure?—The organic carbon and the organic nitrogen are the indications of polluting matter; the ammonia is not polluting; there may be any quantity of ammonia and no pollution.

11,121. But you told us that the carbon and nitrogen were not to be depended upon?—They are not to be depended upon where there is an admixture of sea water, because sea water contains organic matter corresponding very nearly to the organic matter of the sewage.

11,122. What is the indication of sewage?—Ammonia.

11,123. But when the ammonia has gone?—It is all in your favour then, because we have no other proof of the presence of sewage except ammonia.

11,124. (*Professor Williamson.*) Is there any process known to you by which a smaller proportion of ammonia, less than a grain per gallon, can go out, or does go out, from sewage; is there any case established of sewage losing within a definite time an appreciable quantity, or a small fraction of a grain per gallon?—May I ask, do you mean losing by evaporation?

11,125. Losing any how, so as to show that if it is still sewage containing a grain per gallon, the good of that is gone?—I cannot say that I have any facts bearing upon that, but I have noticed over and over again, the disappearance of ammonia from polluted water when the samples have been kept two or three days, and analysed.

11,126. (*Dr. Stevenson.*) May I ask whether you have examined the water for living organisms in that case?—I have not.

11,127. (*Professor Williamson.*) They might have assimilated the ammonia?—In all probability. The ammonia does not evaporate. Sewage will flow for miles and not lose an appreciable portion of ammonia.

11,128, But you have found that after you have collected it, it does lose?—Yes, I have had samples taken, and duplicate analyses made of them, and they show after two or three days none at all.

11,129. (*Chairman.*) Do I understand you to say that ammonia indicates the presence of sewage?—Yes, when it is beyond the quantity normally present in the river under investigation.

11,130. You have it in pure water?—Yes, in a small quantity.

11,131. And in salt water?—Yes, to a certain very small extent.

11,132. You have at Teddington and at Southend, very much the same amount of ammonia?—Yes; that I explained by saying that the ammonia in sea water is only about $\frac{1}{10}$th of the amount of ammonia in the water at Teddington. There is a very small quantity indeed in sea water; what I said was that I should have been surprised if I had found a larger amount of ammonia at Southend, on account of the quantity of sea water.

11,133. (*Sir John Coode.*) The ammonia in itself is not hurtful, is it?—The ammonia is perfectly innocuous.

11,134. If the ammonia had all gone, might the sewage be equally injurious and prejudicial to health as before?—Yes, I think so, because it still contains putrescible organic matter.

11,135. (*Dr. de Chaumont.*) Have you any experiments to show whether there is any alteration in the amount of organic nitrogen, when the ammonia disappears?—I have made experiments with the view of ascertaining that. I was under the impression at one time that the ammonia was assimilated by living organisms, and that it was transformed therefore into organic matter, but the experiments led to a negative result.

11,136. (*Professor Williamson.*) Have you any facts regarding the process by which ammonia disappears, as you conceive it does, in the presence of organisms; do you conceive the organisms assimilate it?—What I stated was, that I made a number of special experiments, with the object of ascertaining whether, when ammonia disappears in this way from contaminated water, the quantity of organic matter increases; and I have obtained, in every case, a negative result. I found that it did not increase when the ammonia disappeared.

11,137. The organic matter altogether; not organised living beings?—I was under the impression that it was absorbed by organisms, and disappeared as organic matter, but I could obtain no evidence of that.

11,138. (*Mr. Bidder.*) When you stated that sewage in the water might be equally prejudicial to health if no ammonia were present, were you referring to water being fit to drink?—Yes, more especially.

11,139. Of course, nobody would contemplate, at the present day, drinking the water of the tidal reaches of the Thames under any circumstances?—No; but still, at low water, a great deal used to be taken by the shipping, and may be yet for aught I know.

11,140. Have you any observation or experiment leading you to believe that sewage in river water is prejudicial to health otherwise than for drinking?—No; I have no observations to show that definitely.

11,141. When I drew your attention just now to a Gravesend sample on Table 12, at low water, from which the ammonia was absent, and asked you what test, in the absence of ammonia, you would refer to for sewage, you said, the organic nitrogen and the organic carbon?—Yes; but I have said, over and over again, that that test is quite unreliable when there is sea water in the mixture.

11,142. I want to draw your attention to this, that in that very specimen, the organic carbon is actually less than in the water at Teddington?—That may be so, but you will find that the organic nitrogen is in a very high proportion to it.

11,143. The organic carbon is ·206 at Gravesend; whereas, if you look at the previous table at Teddington, it is ·324?—Yes; but look at the organic nitrogen in the two places.

11,144. There is not much difference between them; the one is ·1, and the other is ·06; that is not much to boast of?—It is ·05; not more than half as much.

11,145. The carbon, however, is less at Gravesend than at Teddington?—Yes; there is sea water there probably.

11,146. Does sea water destroy the carbon?—No; but sea water does at times contain less organic carbon than this water did at Teddington upon this particular day.

11,147. It is not quite so, because, if you look at Southend the same day, there was more carbon, so that will not do; there was ·3 and ·216?—At low water it was ·216.

11,148. Because there was the purifying influence of the river which helped it?—It was also, at high water, ·202 on September 22nd, in the second high water sample.

11,149. One is at the surface and the other at the bottom; let me draw your attention to that; so that you must take the mean between them; it is not the sea water which has reduced the carbon, because the carbon is less at Southend than at Gravesend; so, does not it come to this, that by the time the river

has reached Gravesend, by every test that you can point to, it is as pure as it was at Teddington, or as pure, if you like, as the sea water?—Not at all.

11,150. What is there that you can point to which will show that the Gravesend water is not as pure as the Teddington water, on the one hand, and the sea water on the other?—The organic carbon, 20 feet below the surface at Gravesend, was ·494, whilst the organic nitrogen was ·149; those are very high numbers.

11,151. Now you have gone below the surface. How do you know that that was not living organic matter?—It may have been living at Teddington for the same reason, but there it was; it was organic matter, whether living or dead. I do not know that it is any the better for being living.

*Dr. E. Frankland.*

6 March 1883.

Adjourned to to-morrow at half-past 12 o'clock.

# TWENTY-EIGHTH DAY.

## Wednesday, 7th March 1883.

PRESENT:

SIR. P. BENSON MAXWELL, IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR A. W. WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
WILLIAM POLE, Esq., F.R.S., *Secretary.*

Dr. EDWARD FRANKLAND, F.R.S., further cross-examined by Mr. BIDDER.

11,152. I have only two or three questions more to put to you; do you know the River Lea?—Yes, I do.

11,153. Can you tell us at all the sewage of how many people is discharged into the River Lea above the intake of the East London Water Company?—That I cannot tell you off-hand, I have a memorandum somewhere about it.

11,154. It is a very large number, is it not?—There is nothing like the sewage that is discharged into the Thames in relation to the volume of water.

11,155. I do not know whether I am approximately right, it is suggested to me that there are about 300,000 people above the intake of the East London Water Company?—I cannot deny it.

11,156. (*Chairman.*) You do not know anything about it?—I do not know anything about it at the moment.

11,157. (*Mr. Bidder.*) You are aware, I presume, of this, that there are a considerable number of sources of pollution in the upper part of the River Thames above the outfalls at Barking, other than the outfalls of the Metropolitan Board of Works?—I should think there are not many, I may say at once that I do not know of any, but I do not mean to say there are none.

11,158. I do not know whether you have heard the evidence which has been given before the Commission, are you aware that the Richmond sewage goes into the upper part of the river?—When I said that, I knew of no other source of pollution, I meant other than sewage; I did not distinguish between Richmond sewage and London sewage. I know that the sewage of Richmond goes in up there; I thought you meant drainage from manufactories.

11,159. Are you aware also that the sewage of a good number of other places, Chiswick and Barnes, also goes in there?—I really do not know how far the sewage of those places is included in the Metropolitan drainage area, therefore it is no use asking me.

11,160. Take it from me that it is not; are you aware that the tributary streams bring in a considerable quantity of sewage?—Yes, that is in evidence in Dr. Tidy's tables.

11,161. Perhaps you are aware also that there is a very large floating population upon the river?—Yes; I am not aware at all how many there may be upon the average at any one time upon the river, but there must be a considerable floating population.

11,162. As regards the pollution higher up the river at Chelsea and Chiswick and this neighbourhood, have you anything which enables you to say that it is attributable to the metropolitan outfalls at Barking rather than to other sources of the kind I have indicated?—Of course my analysis cannot distinguish between Richmond sewage and London sewage, that is quite apparent.

7 March 1883.

11,163. One other matter upon which I desired to put a question to you is this,—you said yesterday, in describing certain experiments of yours with regard to the effect of sewage in water, that, although the amount of oxygen required to oxidise the sewage had diminished by lapse of time, you were of opinion that the sewage was not destroyed because no carbonic acid was formed?—I was not "of opinion," it is a fact that none of it was destroyed, because, if it had been destroyed, carbonic acid gas must have been produced.

11,164. It goes beyond an opinion; it is an absolute fact?—It is an absolute fact.

11,165. Now I will put a few questions to you upon another matter; if it does not follow that carbonic acid gas was formed, yet the oxidation of the sewage produced other combinations which are equally destructive of the sewage as sewage?—That is a very difficult question to answer. I quite agree with you that other combinations would be formed, but we know nothing of them as to whether they are more or less noxious than sewage.

11,166. The sewage has been oxidised or burnt, and the chemists tell us that those are convertible terms,—it is none the less burnt because it has formed another compound of the carbon and the nitrogen with carbonic acid?—You cannot say that it is burnt at all until it is resolved into its products of combustion; the products of combustion are carbonic acid, water, and nitrogen, and those were not formed in this experiment.

11,167. Combining with oxygen is combustion, is it not?—Scarcely; you would not say you burnt up alcohol when you converted it into vinegar.

11,168. Is it not the case that in experiments such as yours, the quantity of carbonic acid that would result from the absorption of the amount of oxygen that was indicated would be so small as not to be distinguishable within the limits of experimental error?—Oh dear, no. I should think probably that a 50th part of it would be distinguishable.

*Dr. E. Frankland, F.R.S.*

7 March 1883.

11,169. I am not a chemist myself, but I have some eminent chemists behind me, so I do not ask these questions without some instruction, and I ask you to reconsider that answer. What, for instance, would be the amount of carbonic acid that would result from your experiment; it is suggested to me that it would be so minute as to be within the limits of experimental error?—Unfortunately the oxygen is expressed in that report by weight, and it would take some time to convert that into volume; the carbonic acid, on the other hand, is determined by volume and not by weight; it would be difficult perhaps to determine it by weight, but there would be no difficulty in determining it by volume.

11,170. Is that in the 6th Report of the Rivers Pollution Commission?—Yes, at page 138; the weight of dissolved oxygen in the mixture before it was enclosed in tubes was ·946, that is to say, there were in 100,000 parts of the water ·946 of a part by weight of oxygen, that is not much less than one part by weight; 16 parts by weight of oxygen would produce 22 parts by weight of carbonic acid, by combining with the carbon. Now nearly the whole of the oxygen is absorbed, you will observe, in the 168 hours, and the quantity of gas boiled off in the shape of carbonic acid was very large indeed; there was no difficulty indeed in estimating it, but I cannot tell you how much there would be unless I knew the contents of the bottles in which the experiments were made.

11,171. Now I will ask you this; there is always a certain amount of carbonic acid in the water, is there not?—Yes, certainly; that was determined in the initial experiment.

11,172. The actual quantity of carbonic acid that would result would depend upon the size of the bottle; that is obvious, but the relative quantity of carbonic acid resulting from this oxidation of the sewage to that which is naturally in the water would be so small as to be within the error of experiment, would it not?—No, it would be nothing like that minuteness; it would be a considerable amount.

11,173. I do not know within what limits you could determine the carbonic acid present, would it be within one per cent. or two per cent.?—You can determine the carbonic acid with very great precision indeed to one-tenth of one per cent. in a gaseous mixture.

11,173*a*. Do you mean present in water?—Yes, present in water.

11,174. Do you mean to say that the errors of experiment are not more than that?—No; I have determined in the air a percentage of carbonic acid which never rises, or did not rise in these experiments, to more than ·01 per cent.; I have determined that over and over again with very tolerable accuracy, that is one-tenth of what I am speaking of now, namely, 100th of a per cent.

11,175. Where is it recorded in this report that there was no production of free carbonic acid?—On page 138 there is a paragraph beginning "It is thus "evident," and at the end of that you will find it stated "whilst, if the sewage had been converted into "inorganic compounds, the carbonic acid as one of "these compounds must have increased in quantity."

11,176. I do not see any determination of the amount of carbonic acid here; I see a general statement?—It was carefully determined before and after the experiment; and there is also in that same paragraph this passage, "But the experiments showed "that, in fact, no sewage whatever was so converted "or destroyed even after the lapse of a week, since "the amount of carbonic acid dissolved in the water "remained constant during the whole period of the "experiment." Now the carbonic acid, I may mention, was determined in each of the six cases.

11,177. What had the sewage been converted into?—Very little of it was converted at all, but what it was converted into, I cannot say.

11,178. (*Dr. de Chaumont.*) Have you any evidence of the absorption of the carbonic acid by the bacterial bodies in the water?—I have nothing very positive; I have made experiments of that kind by putting putrescent mutton broth into an atmosphere of carbonic acid, and the liquid generated bacteria, and, as far as my memory serves me, the volume of the gas did not perceptibly diminish for a week or a fortnight during the time that operation was going on; but I did not make any accurate measurement of that, it was merely a measurement by the eye.

11,179. There is no evidence of the absorption of dissolved carbonic acid in water by the bacteria?—No, there is no evidence that I am aware of.

11,180. (*Dr. Stevenson.*) You would not agree that it is impossible for these organisms to live in the absence of oxygen?—No, certainly not.

11,181. (*Mr. Bidder.*) In air, as I understand, it is a very simple thing to determine with great accuracy the percentage of carbonic acid present?—Yes, it is.

11,182. But in water is it not determined by boiling?—It is determined by boiling—a known volume of water in vacuo—until it ceases to give off any trace of gas.

11,183. In point of fact, it is practically impossible, is it not, to eliminate the whole of the carbonic acid in that way?—I do not think so; when you say the whole of it, there might be a 10,000th part of it left behind, but practically, you get rid of it.

11,184. But within one per cent. you cannot determine it, can you?—I have made many scores of determinations of this kind, and I have not found any difficulty in doing so.

11,185. I believe about 45 parts in 100,000 is the normal proportion of carbonic acid in water?—That depends altogether upon what the source of the water is. In chalk water you will have more; you cannot put it in that way.

11,186. (*Chairman.*) There is no settled quantity, we may take it?—No, because in chalk water there is a good deal of carbonic acid held in combination until it is boiled.

11,187. Science has not recognised a fixed quantity of carbonic acid as the standard quantity for water?—No, it varies very much indeed, within very high limits. Might I say within what limits I have found the carbonic acid to vary. In rain water I have found in 100 cubic inches ·128 of a cubic inch; in Cumberland mountain water I have found ·281 of a cubic inch; in Loch Katrine water ·113; in Thames water 4·021; and in a deep chalk well water 5·520; so that the variations are very wide.

11,188. (*Mr. Bidder.*) I am asked to clear up one or two minor errors in the table you put in yesterday, with a view of ascertaining the amount of matter in the sewers. I refer to Table B., at page 18; do you observe that you counted one sewer twice over, which raises the average?—No, I did not know that.

11,189. Will you look at the second observation, June the 11th, 1857, Savoy Street; 19·26 mineral, 13·52 organic, total 32·78. Now take the 11th observation, you will find the same figures exactly repeated?—Yes, you are right.

11,190. Now let me draw your attention to another little inaccuracy while we are about it; will you turn to section 4, page 22?—I have it.

11,191. You have one tremendous figure that does great work for you in whipping up the average, namely, that 209·25 at Savoy Street?—But there is another nearly the same below,—210.

11,192. But keep your mind please to the third—you took that from Messrs. Hofmann and Witt?—Yes.

11,193. Are you aware that that figure is not the suspended matter, but the suspended matter *plus* the dissolved matter?—No.

11,194. I think you will recognize the source of your information if I hand this to you (*handing a book to the witness*). I do not find any such figure as that for suspended matter in the authority from which you take it?—I find that the total as given for that day is 296·97.

11,195. That is the suspended matter *plus* the dissolved matter?—Yes, but the figure I have given is 209·25.

11,196. Where did you get your figure of 209 ?—I got it by deducting for dissolved matter, 87·72 grains per gallon, which was found by Hofmann and Witt in the Northumberland street sewage on May 28th, 1857. You will find it in the analytical table on page 14 of their Report.

11,197. Whilst taking these observations for Messrs. Hofmann and Witt, why did you omit certain observations of theirs which give very small results, such as on March the 18th, the Falcon Brook, and on March the 20th, the Earle Brook ?—Those are very minute sewers, I think.

11,198. Are they ? They are two of the largest, I am told ?—The flow is not given.

11,199. (*Chairman.*) Why did you omit them ?—I omitted them because it was obvious that the sewage from these sewers had been subjected to some kind of subsidence before the samples were taken. These samples contained only 3·54 and 2·88 grains respectively of suspended matter per gallon;—proportions which have never been observed in sewage either before or since. The nearest approach to them in the analytical table at page 14 of Hofmannn and Witt's Report is 15·38 grains per gallon in the Fleet sewage bofore rain on April 10th, 1857.

11,200. (*Mr. Bidder.*) Is not there another consideration that would induce you to reject all these earlier observations of the date of 1857, and that is that the London sewage in later years is considerably more diluted than it was in 1857, owing to the increased quantity of water supplied per head of the population ?—It is more diluted. At the same time its character is not changed by merely discharging it at different outfalls.

11,201. But what I mean is this; supposing you had the same amount of road drift coming down in 1857, and only half the quantity of water supplied to the population which is now supplied, you would have twice the number of grains per gallon that you would get now, and if you multiply the number of grains into the doubled supply of water you get a double supply of material brought down ?—Yes, but you are putting it in a tremendously exaggerated form when you put it at double.

11,202. I asked the question because at page 29 of the Rivers Pollution Commission, Third Report, for which, I presume, you are responsible —— ?—For which I am responsible with my brother Commissioners.

11,203. You gave there the sewage of various towns, amongst others, London, and you put this note : "Having given the 1857 observations," and I may say I believe they are the very observations you are dealing with to-day ?—I know that I state that the results of Dr. Hofmann's and Mr. Witt's experiments showed that the sewage was more concentrated at the time than it was when the Report was written, and I attribute that to the larger water supply at the later date.

11,204. "They show, when compared with our more "recent analysis, that the London sewage is now con- "siderably more dilute than it was in 1857" (that was 12 years previously) "owing doubtless to the "increased quantity of water supplied per head of "population" ?—Yes, I agree to that, but the extent of the dilution is given by the chlorine in the sewage in the two periods.

11,205. Because you found 100 grains to the gallon in the old days, in which there was a much less quantity of water supplied to the public, would it be fair to apply that to the much larger quantity of water supplied at the present day ?—Perhaps not strictly so ; it would come out from 90 to 93 instead of 100.

11,206. But surely you had not such a small difference as that in your mind when you used the expression "is now considerably more dilute."

The *Chairman* suggested that the witness should amplify his evidence on this point on a subsequent occasion.

11,207. (*Mr. Bidder to the witness.*) Before I leave the table in your Report I will ask you this : before you got out your grand total of tons of suspended matter, you said you took the rainfall over the 122 miles of the metropolitan area ?—Yes, I so stated it in the Report, 122 square miles of the area of the metropolis and 20 per cent. allowed for the evaporation ; and then again, it is not, as you put it yesterday, that I put these amounts down for the sewage of the 24 hours whilst that sewage might be coming down only for an hour or two. What is done in the table is to attribute to the whole of the rainfall the composition shown by the analysis of a portion of it.

11,208. Less than 20 per cent. of it ?—Yes.

11,209. Included in that, for instance, there are some five or six miles which are the river itself; that is to say, the area represented by the River Thames ; you assume that the rain which falls into the Thames itself brings down 100 grains of grit, or whatever it is, to the gallon ; you have done so, have you not ?—I have not allowed for the area of the river itself.

11,210. Again you have included, have you not, 24 or 26 square miles which are not included in the area drained through the Metropolitan sewers into the River Thames at all ?—I took these figures from the Registrar-General's return.

11,211. (*Chairman.*) You do not know the fact whether or not it is all drained by the metropolitan sewers ?—I am not aware of the facts either one way or the other.

Re-examined by Mr. Lumley Smith.

11,212. I wish to ask you one or two questions upon this important matter as to the extent to which oxidation goes on. My learned friend Mr. Bidder drew your attention to some experiments that were made by Dr. Tidy, and published in the Journal of the Chemical Society, that is so, is it not ?—Yes.

11,213. I believe they were published in the journals of the Chemical Society for May 1880 ?—Yes, they were.

11,214. You were asked one or two questions by my learned friend as to the ground you had for forming an opinion that the results arrived at were not to be relied upon ?—Yes ; I was taken by surprise by that question because I had never thought about these experiments since the time Dr. Tidy and I had this discussion before the Chemical Society.

11,215. When you speak about discussion, a paper of yours was published in the journals of the Society for 1880 ?—Yes.

11,216. Will you tell us, when you say you were "taken by surprise," what reasons you had for forming the opinion that they were not to be relied upon ?—In the first place, I had Dr. Tidy's own statement in which he said "I am bound to acknowledge that the "results showed altogether against my views of oxida- "tion." Then I objected in the next place that those experiments do not represent water running in the river at all.

11,217. The experiment Mr. Bidder said was an experiment of one mile in eight hours ?—Yes, those were the experiments I was alluding to ; they were made in troughs.

11,218. They were made in troughs ten feet long ?—Yes.

11,219. There were 20 of them ?—Yes.

11,220. At the end of each trough there was a fall of some few inches into the succeeding one ?—Yes, and the troughs were lined with pieces of glass.

11,221. After passing through the 20 troughs of ten feet long, the water——

(*Mr. Bidder.*) I think you are not quite fair to Dr. Tidy in quoting that sentence : "I am bound to "acknowledge that the results showed altogether "against my views of oxidation"; because then he goes on to say, "for the following reasons."

11,222. (*Mr. Lumley Smith.*) At the end of the journey the water was received into a cistern, was it not ?—Yes.

*Dr. E. Frankland, F.R.S.*

7 March 1883.

11,223. It was then pumped back into the upper cistern ?—Yes.

11,224. So that in the course of a mile there would be some 26 pumpings or thereabouts ?—Yes, I suppose there would be.

(*Chairman.*) To put it shortly, you objected to the system pursued by Dr. Tidy.

11,225. (*Mr. Lumley Smith.*) That would have an aërating effect in itself ?—Certainly ; it is a very good method of aërating the water.

11,226. The first experiments, it would appear, were made in the open air, and before the troughs were lined with glass ?—I am not aware of that.

11,227. (*Mr. Bidder.*) You say you were not a party to those experiments at all ?—No, I did not see the experiments made ; I had only Dr. Tidy's description of them, and I did not remember that at the time.

11,228. (*Mr. Lumley Smith.*) Having described the nature of the experiment, will you explain how far that is likely to show us the extent of the oxidation ?—In the first place, I imagine that sewage running in this small trough, and presenting, therefore, a very large surface, not merely to the air in proportion to its bulk, but (what is more important) a very large area relatively to the glass sides of the trough, is in a very different condition from the sewage flowing in the Thames when only a very small proportion of the water is in contact with solid matter. I have shown over and over again that water in contact with solid matter, that is to say, water touching a bottom composed of stones or silicious sand, is very rapidly purified ; therefore, I consider that touching the sides of the glass would have a considerable effect in oxidising the sewage flowing through the troughs. Secondly, I believe that the sewage employed was not filtered, but was unfiltered sewage, and if this were so, it could hardly pass through these troughs for the distance it did at the very slow rate of a mile in eight hours without leaving some of the suspended matter either upon the surface of the glass or between the glass and the side of the trough, to which the air would gain access. If that were so, the sewage matter so removed would represent so much sewage matter which had been oxidised according to Dr. Tidy's interpretation of his experiment. In the third place, I believe that some at least of the reduction of the organic elements which Dr. Tidy observed in his latest experiment was due to the decomposition of the urea ; the urea would appear as organic carbon and organic nitrogen, but after it had been decomposed into carbonate of ammonia it would disappear from that result, and would then be so much mineral constituent, which would not be estimated as organic at all. Now, I have proved over and over again, and everybody knows, that urea is very rapidly decomposed when it is in contact with any putrid organic matter, and especially with the residue of previous urine. Everybody knows what an offensive thing a railway urinal is from that cause, and the effect upon the fresh urine of the previous urine is due to the presence of bacteria in the old urine, which immediately propagate at an enormous rate in the fresh urine, and convert the urea into carbonate of ammonia. As soon as the urea is so converted the bacteria all die ; that I have proved by experiment, therefore I conceive that Dr. Tidy fails to produce the effects which at first he attributed to oxidation, because, although at first the nidus for the bacteria, that is to say, the space between the glass plates and the sides of the trough, was not sufficient to develop sufficient bacteria to work upon the urea, yet after the troughs had been in use for a considerable time, and became in a slight degree, I do not mean to the same extent, but in the same condition, as a railway urinal, they generated bacteria which worked upon the urea. That result which he arrived at I conceive to have been partly due to the decomposition of the urea, and only in part to the oxidation. The difference between Dr. Tidy and myself is shortly this,—I say oxidation takes place very slowly, and Dr. Tidy says that it takes place very rapidly, in running water.

11,229. Do those experiments at all alter your view with regard to the River Thames that oxidation takes place very slowly ?—Not in the least.

11,230. (*Professor Williamson.*) With regard to the construction of Dr. Tidy's troughs, you said there were glass plates against the sides of this V-shaped trough ; were they cemented against the trough, or were they placed loosely in it ?—I understood that they were placed loosely in the trough with the edges coming together at the bottom, but Dr. Tidy is here, and he could explain it.

11,231. (*Sir John Coode.*) Dr. Frankland seems to assume that the fluid got ready access between the back of the glass and the trough ; but if it were cemented so that access could not be obtained, that argument would fall to the ground ?—It would so far.

11,232. (*Dr. Stevenson.*) Would bacteria collect in the little inequalities of the river bed ?—I think, if the water in the river were in a putrescent condition, the probability is that the mud of the river would be found to swarm with bacteria.

11,233. (*Mr. Lumley Smith.*) Passing from that, your attention was drawn by my learned friend, Mr. Bidder, to the fact that upon the 22nd of September, at Gravesend, as appears by your Table 12, page 13, there was an absence of ammonia. If you look at Gravesend, you will see that one foot below the surface at low water the amount of ammonia is nothing, and my learned friend, Mr. Bidder, drew your attention to the fact, and asked you whether that did not show, as far as the ammonia test was concerned, that there was no sewage at Gravesend ?—Yes, I was asked that, but I have already explained that the absence of ammonia is no proof of the absence of sewage, while the presence of ammonia is evidence of the presence of sewage.

11,234. In addition to that, I believe you wish to draw attention at the same time to the observation '20 feet below the surface' ?—Yes, I think Mr. Bidder was hardly fair in seizing upon one sample of water as representing the composition of the river.

*Mr. Bidder* objected to the statement, alleging that he had called the attention of the witness to both the samples in question.

(*Witness.*) I wish to say that this sample taken at one foot below the surface was only one of two samples taken at the same time, the other being taken at 20 feet below the surface, so that it would only be fair, I conceive, to give the average of those two samples as representing the condition of the river at that point, that is to say, as containing ·494 of organic carbon and ·149 of organic nitrogen.

11,235. (*Chairman.*) The ammonia is ·060 ?—Yes, but I wish especially to draw your attention to the organic carbon and the organic nitrogen. If we take the mean of these, then we get, as the composition of the water at Gravesend at low water upon the 22nd of September, organic carbon ·350 and organic nitrogen ·125. Now, if we mixed 10 gallons of average London sewage with 90 gallons of pure water, we should get a liquid which would have almost exactly this composition of the water at Gravesend. Now the chlorine determination of the water at Gravesend at this time shows that 54·2 per cent. of it was sea water. The composition of the sea water at high water at Southend (which is the thing I happened to take in this case) was organic carbon ·257 and organic nitrogen ·214, making together ·471, whilst the same organic elements at Gravesend were organic carbon ·350 and organic nitrogen ·125, making together ·475 ; therefore the composition of the sea water as regards organic matter, and of the Gravesend water, is practically identical. We can therefore eliminate the sea water from the result, as it did not make any difference in the result. Now if we take the composition of the water at Erith, the next station above Gravesend, in the same table, at low water, we find that the organic elements in the two low-water samples, taking the

average of the organic carbon and the organic nitrogen at Erith, and adding the necessary quantity of sea water to make a quantity with the same components as that at Gravesend (for there was only a little more than a quarter of the water at Erith at this time sea water, whilst more than half of it at Gravesend was sea water), then the composition of the river water at Erith, calculated from its composition at Gravesend, and allowing nothing whatever for oxidation, would come out carbon ·378 and nitrogen ·142, figures not very different from those found at Gravesend, the mean being there organic carbon ·350 as against ·378 at Erith, and organic nitrogen ·125 as against ·142 at Erith. Therefore I say the composition of the water at Erith confirms to a very great extent the composition of the water at Gravesend; that shows that between Erith and Gravesend, I forget how many miles it is, practically no oxidation takes place.

11,236. (*Mr. Bidder.*) But let me draw your attention to one thing, that, according to your own Table No. 11, the water when it comes over Teddington Weir has a lot of carbon and nitrogen in it, and you have been attributing to sewage that proportion which comes over Teddington Weir?—But you must not assume that the Teddington organic matter cannot oxidise, whilst the sewage organic matter does. If the oxidation took place at the rate you are contending for, then all that organic matter would have been oxidised long before it got to Gravesend.

11,237. (*Mr. Lumley Smith.*) The Teddington element must be eliminated from both?—Yes; therefore you may say that the Teddington water would arrive at the northern outfall as pure water.

11,238. (*Chairman.*) You adopt Mr. Bidder's theory when it is opposed to your views, but your own candid opinion in respect to oxidation is opposed to his?—Yes, only in discussing it I am assuming for the purpose of argument what he assumes, namely, that there is rapid oxidation.

11,239. But you believe that there really is not that rapid oxidation?—Yes, I believe that all the organic matter which comes over Teddington Weir, or very nearly the whole of it, goes past Gravesend.

11,240. Then Mr. Bidder says, that being your opinion, does not that interfere with these calculations?—It interferes to some extent with the proportion of sewage which I mentioned; it would be less than 10 per cent. I do not suppose there would be 10 per cent. present, I was only following out the calculation we should get upon Mr. Bidder's supposition. I do not suppose we should get as much sewage, but there must have been a considerable amount in order to raise the organic nitrogen from ·06 and ·05 to ·149 and ·1.

11,241. (*Mr. Bidder.*) But take the carbon. You will see at Erith it is ·414, at Teddington it is ·321, exactly three-fourths of it?—Yes; of course those are entirely different dates.

11,242. I beg your pardon?—What I mean is that the water coming over Teddington Weir does not get to Gravesend upon the same day or even the same week. I do not think you can fairly represent what is passing Gravesend by what is passing over Teddington Weir.

11,243. (*Dr. Stevenson.*) Does not the amount of organic matter in the water influence the rate of oxidation—Suppose you take two waters, one containing a grain of organic matter and the other ten grains, would they proceed at the same rate of oxidation?—That I am unable to say from any actual experiments I have made; we have the approximate rate of oxidation in the Irwell in the experiments which I gave yesterday, and I have also determined the approximate rate of oxidation in the Thames water in a flow of 4 miles from below Reading to Shiplake Mill.

11,244. Have you made any observations upon this point, that when you have water containing a small quantity of organic matter that is very difficult to remove by oxidation?—I have found that if a water containing a small quantity of organic matter has been subjected for a long time to oxidising influences, it is very difficult to get rid of that. That I conceive to be the condition of the organic matter in sea water which is very difficult to touch, permanganate of potash will not touch it.

11,245. (*Mr. Lumley Smith.*) You have struck out from your table, have you not, some of the observations which you consider abnormal?—Yes, I struck them out because I wanted to get as fairly as possible an average of the composition of sewage under different conditions of rainfall in dry weather, and also with the degrees of rainfall which I give in these tables, and I should consider I have done this very fairly.

11,246. I suppose when you have only a few observations you can hardly take them so fairly as when you have a larger number and take the average?—No, the fewer you have the less valuable your average becomes.

11,247. With regard to Table B can you give me the average, taking in all those which have been ruled out as abnormal?—Yes, I have had calculated for me that average. Taking the whole of the 49 samples—taking into account all those which have been ruled out in my table, the average suspended matter in those analyses is 53·4 grains per gallon—that is under all the conditions of rainfall put together taking all the 49 samples.

11,248. (*Professor Williamson.*) Allowing of course for the relative qualities to which they refer—I mean if you have a great quantity of sewage coming out after a storm and make a computation of the amount of it, do you allow for that?—No, that has not been done in this case.

11,249. You assumed the quantities to be equal?—Yes, I assumed the quantities to be equal—I had not time to take the other out—That would require a day or two. That has been taken out in the table I have produced for each day's rainfall, but to re-calculate the whole upon this basis, I could not do it in the time.

11,250. (*Mr. Lumley Smith.*) What do you mean by the 49 samples?—The 49 samples are I believe the whole of those contained in my table which have been analysed.

(*Mr. Bidder.*) There are far more than 49, are there not?

(*Sir John Coode.*) All that we want to know is the extent to which the average would be affected. If you will endeavour to get us that as briefly as possible that will be all that we shall require.

(*Mr. Lumley Smith.*) I will proceed now to another point. A question was asked you with regard to your section 4, upon page 20. Can you give me from this Report upon the Metropolitan Drainage, 1867, the amount of suspended matter in the Savoy Street sewer?

(*Sir John Coode.*) What you propose to do now is to get us the correct figure?

(*Mr. Lumley Smith.*) The figure I have of the total grains is 209·25.

(*Witness.*) I am referring to page 15 of the Metropolitan Main Drainage Report of 1867. The previous gives the total of the suspended and of the dissolved matter in the Savoy Street sewer.

11,251. If you refer to the next page that takes off the dissolved matter, does it not?—Yes.

11,252. If you subtract the one from the other, that would give you the amount of suspended matter.

(*Mr. Bidder.*) But you are subtracting one thing from quite another—you are substracting the mean of a number of days from the result of a particular day which is a very abnormal day.

*The Chairman* intimated that the witness should be allowed to go into the calculation at leisure.

11,253. (*Mr. Lumley Smith.*) You were asked about the catch pits in the metropolis. You have made experiments about catch pits both in the metropolis and in the country, have you not?—I have not made actual experiments to ascertain what proportion of the suspended matter is carried into the sewers and what remains in the catch pits.

*Dr. E. Frankland, F.R.S.*

7 March 1883.

11,254. You gave us an opinion that a very small proportion is caught in the catch pits. From what did you derive that opinion?—My experience was from observing what is caught in sewage tanks. If you have a stream of sewage running through a tank whilst a storm is going on, there would be very little deposit take place there. The Rivers Pollution Commission mentioned that very specially in their Report upon Mining.

11,255. (*Sir John Coode.*) You mean the agitation is so great that very little will fall?—Yes, it requires almost entire rest to get anything like perfect subsidence.

11,256. (*Mr. Lumley Smith.*) You are aware, are you not, how the catch pits in the metropolis are made?—Yes.

11,257. You stated that the taking of the samples at the outfalls, was stopped at the time of heavy rainfall, so that you had a difficulty in getting the amount of suspended matter in times of heavy rainfall. You say, with regard to Mr. Keates's observations, that they ceased in times of heavy rainfall?—I said they ceased, but why, I did not know.

11,258. How are they recorded?—They are recorded in the report to the Metropolitan Board of Works which was produced at the former inquiry. I have not got it with me, but I entered the results in a table in my report from that report of Mr. Keat's observations.

11,259. You are dealing with what is published in that report?—Yes.

11,260. (*Chairman.*) What observations are you referring to?—Those marked on pages 18, 19, and 20 of my own Report with two asterisks.

11,261. (*Mr. Lumley Smith.*) Do you know what report you got that from?—I think it was published some time in 1880.

11,262. You were asked whether, according to your calculations, you were not showing (I think my learned friend Mr. Bidder put it) that about seven times as much, would have to go into the sewers as they would hold?—Yes, I think Mr. Bidder objected to my assumption, suggesting that the whole of the rainfall when it was on one occation 3,676,000,000, or 2·5 inches, could not possibly get into the Thames through the sewers; and I said I could not conceive any other way in which it could get into the river, except through the sewers.

11,263. (*Chairman.*) Have you any observation to make upon that?—Yes, I have, in the meantime, an extract from the report of Sir Joseph Bazalgette which throws some light upon that matter. This is Sir Joseph (then Mr.) Bazalgette's report upon the source of the Kent drainage, "To the Honourable the Metropolitan Commissioners of Sewers," with respect to the Greek Street sewer 1853.

(*Mr. Bidder.*) But the sewers were not made then.

11,264. (*Chairman.*) You say there is some observation of Sir Joseph Bazalgette which seems to throw some light upon this question of the 3,676,000,000?—Yes, I think it does. Sir Joseph Bazalgette says: the largest quantity of rain which fell in London in one day during the wet season of 1852 measured 1½ inches, but storms amounting to 2½ inches in a day, although of rare occurrence have been recorded, and these would deliver into high level sewer (Sir Joseph Bazalgette is speaking now of the drainage scheme which was then under consideration) 45,000 cubic feet per minute which it is capable of discharging upwards of 46,000. The low level sewer will discharge 21,400 cubic feet per minute, and it is here proposed that the existing main sewers in the low districts should act as reservoirs during such extraordinary storms. From their construction and the remarkable flatness of their level, they are peculiarly adapted to this object and it is estimated that on these occasions, they would store the surples floods without the rising of the latter to an inconvenient height, and would again deliver their contents into the Thames low water, or intercepting sewer as it became free to receive them. Thus the provision of engine power for such rare occasions would be saved, and the existing sewers made available. The next extract is from a report by Sir Joseph Bazalgette submitted to the Metropolitan Commissioners of Sewers on January 22nd. 1855. "In those portions of "the district where drainage outfalls are required in "addition to the interception of sewage, provision for "storm waters becomes necessary, and for districts of "the extent, level, and general character of those "now under consideration, the main outfall sewers "should be capable of discharging 2½ inches of rain "in 24 hours, as is more fully set forth in my report "upon the southern drainage, and with the exception "of this difference, their dimensions have been calcu-"lated as already explained." So that he says that "2½ inches can be discharged," and that was the rainfall I have named.

Examined by the Commission.

11,265. (*Dr. Stevenson.*) I wish to ask you about the red worms; I do not know whether we quite understand you about the red worms found in the Thames. You spoke of them as being characteristic of the sewage?—Yes, I consider them chacteristic of the sewage. I have never found them except in mud that has come from a sewer.

11,266. You have never found them for instance in the higher hills of Surrey, and in ponds with vegetable matter only in them?—No.

11,267. Then how do you account for their disappearance from this part of the Thames; we have it in evidence that they were formerly abundant at Hungerford Bridge?—That was just at the outfall of the Northumberland sewer which came out through Scotland Yard, and entered the river at Hungerford Bridge.

11,268. But why have they disappeared and gone lower down the river; how do you account for that?—My observations have shown me that the worms have disappeared from Hungerford Bridge, and have appeared lower down the river.

11,269. (*Chairman.*) One witness stated that there were none of these worms?—I found them in several places, three years ago, when I was inspecting the river for the Thames Conservancy Board.

11,270. (*Professor Williamson.*) You found them in places where there was a sewage deposit?—Yes.

11,271. (*Sir John Coode.*) Your idea is that the worms follow the sewage?—Yes.

11,272. That is the very reverse of the evidence which was given by the fishermen who say they have disappeared from where they used to find them.

11,273. (*Dr. Stevenson.*) With regard to the urea, I think we have it in evidence, that a considerable quantity of urea would reach the outfalls; Do you find any quantity of urea in the Thames or in the neighbourhood of the outfalls when the sewage is being discharged?—I have never found it in the Thames, but I cannot say that I ever looked for it;—it is not a very easy thing to detect in polluted liquid.

11,274. Have you formed any opinion as to whether much of it would reach the Thames?—Yes. I think a considerable portion of it would reach the Thames, and, once mixed with a large quantity of fresh water, I believe its destruction proceeds then very slowly. From experiments which I have already described to the Commission as to the mixing of urine with the Kent Company's water, I found that the urea was decomposed with extreme slowness when it was mixed with a large quantity of fresh water.

(*Professor Williamson.*) There were no bacteria to do it?—No, they could not live in so dilute a solution. Dr. Stevenson asked me, I think, yesterday, about organic matter being very rich in nitrogen; there is guanine containing one part of nitrogen to ·857 of carbon—guanidine contains one part of nitrogen to ·285 of carbon—allantöin contains one part of nitrogen to ·857 of carbon—urea contains one part of nitrogen

to ·428 of carbon, and uric acid one part of nitrogen to 1·07 of carbon. Those are all substances which may be present in sewage especially the urea which we know is present and guanine is a thing which is likely to be present in sea water.

11,275. They are all products of the decomposition of urine?—Yes.

11,276. (*Dr. Stevenson.*) You know of no bodies other than those produced by the decomposition of urine which would give that result?—No, I think not.

*Er. D. Frankland, F.R.S.*

7 March 1883.

The witness withdrew.

Dr. CHARLES MEYMOTT TIDY, recalled and further examined.

11,277. (*Chairman.*) What do you wish to say about the troughs used in your experiment to which reference has been made?—All the troughs were very carefully washed out before the analysis was made. I have no reason to believe there were any leakages between the glass slides and the sides of the trough. The glass slides were very accurately ground and they were cemented to the wooden troughs with cement.

11,278. (*Sir John Coode.*) Did you notice any matter attaching to the glass after the experiment?—I did not. I must say that the experiments occupied something like seven months, and a place was taken specially on purpose to carry them on.

11,279. You did examine the glass to see whether there was any foreign matter attaching to it?—Yes, certainly. And with regard to a remark of mine that a great many of the results went against the theory of oxidation, I should explain that it was done out of doors. It was a very large apparatus, and it was very difficult to keep the blacks out, and it was not until I had adopted a very large number of devices to keep the blacks out, that I got any reliable results. I think it is right to explain that it went against my views on account of the blacks getting into the troughs.

*Dr. C. M. Tidy.*

The witness withdrew.

Professor JOHN THOMAS WAY, F.C.S., called in and examined.

11,280. (*Mr. Balfour Browne.*) You are a consulting chemist, a Fellow of the Chemical Society, a Fellow and Member of the Council of the Institute of Chemistry, and were formerly Consulting Chemist to the Royal Agricultural Society?—Yes.

11,281. And you were also, I think, one of the members of the Royal Commission on Sewage?—Yes, Lord Essex's Commission.

11,282. That Commission sat, I think, in the years 1857 to 1865?—Yes, it sat for eight years.

11,283. You also acted upon the first Royal Commission with respect to Rivers Pollution, did you not?—Yes.

11,284. That Commission, as the Commissioners know, reported upon the Rivers Thames, Lea, and so on?—Yes.

11,285. You have had a very lengthened experience in relation to water supply and sewage?—I have.

11,286. Have you got beside you the results of the determinations of chlorine in the samples of water collected in the Thames and examined by you?—I have.

11,287. (*Chairman.*) You did examine certain samples?—I have examined a great number of samples.

11,288. (*Mr. Balfour Browne.*) Your table is at page 5 of the blue tables that were handed in by Mr. Baldwin Latham. I think what was handed in by Mr. Baldwin Latham was a resumé of the whole of your experiments, and you are now going to hand in the particular determinations of the samples submitted to you?—If you allude to the pamphlet by Mr. Baldwin Latham, I think it was a resumé of the first set of samples that were examined, but I think it would be better if you would allow me to put them in the form in which they were delivered, which is really that of date.

(*Chairman.*) We have, at all events, this resumé laid before us.

(*Mr. Balfour Browne.*) You have only two columns of the resumé.

(*Chairman.*) These tables represent, in fact, the work of Professor Way, and what you want to ascertain from Professor Way is, that he did make these analyses and that they are correct.

(*Witness.*) Yes, but I wish, if I may be allowed, to put in the full particulars.

*The same were handed in and were as follows.*

*Prof. J. T. Way, F.C.S.*

DETERMINATION OF CHLORINE IN SAMPLES OF THAMES WATER.

*Spring Tide.*—September 14th, 1882.

| | Chlorine Parts per 100,000. | | | |
|---|---|---|---|---|
| | High Water. | | Low Water. | |
| | 1 foot from Surface. | 20 feet from Surface. | 1 foot from Surface. | 20 feet from Surface. |
| **TEDDINGTON.** | | | | |
| A.* | 1·8 | 1·7 | 1·7 | 1·7 |
| B. | 1·7 | 1·7 | 1·7 | 1·7 |
| C. | 1·8 | 1·7 | 1·7 | 1·7 |
| D. | 1·7 | 1·7 | 1·7 | 1·7 |
| E. | 1·7 | 1·7 | 1·7 | 1·7 |
| Average of Position | 1·74 | 1·7 | 1·7 | 1·7 |
| Average of Position and Depth | 1·72 | | | |
| **CHISWICK.** | | | | |
| A. | 3·8 | 4·2 | 1·9 | 2·0 |
| B. | 5·2 | 8·0 | 2·0 | 2·0 |
| C. | 3·2 | 3·7 | 1·9 | 1·9 |
| Average of Position | 4·1 | 5·3 | 1·9 | 1·9 |
| Average of Position and Depth | 4·73 | | 1·93 | |
| **ST. PAUL'S PIER.** | | | | |
| A. | 211· | 212· | 3·8 | 3·8 |
| B. | 215·4 | 235· | 3·7 | 3·7 |
| C. | 196·2 | 196·7 | 4·3 | 5·2 |
| Average of Position | 207·5 | 213·9 | 3·9 | 4·23 |
| Average of Position and Depth | 210·7 | | 4·06 | |
| **DEPTFORD.** | | | | |
| A. | 424· | 438· | 45·4 | 43·4 |
| B. | 443·7 | 451·5 | 39·4 | 43·4 |
| C. | 434·8 | 439·8 | 57·2 | 65·1 |
| Average of Position | 434·2 | 443·1 | 47·3 | 50·6 |
| Average of Position and Depth | 438·1 | | 48·9 | |
| **NORTH WOOLWICH.** | | | | |
| A. | 662·6 | 668·5 | 163·7 | 191·3 |
| B. | 676·4 | 684· | 158·8 | 195· |
| C. | 664·6 | 675·4 | 174· | 196· |
| Average of Position | 668· | 675·8 | 165·5 | 194· |
| Average of Position and Depth | 671· | | 179·7 | |

* The letters A., B., C., &c., correspond with points at equal distances across the River. In all cases commencing from the south side.

*Prof. J. T. Way, F.C.S.*

March 1883.

| | Chlorine Parts per 100,000. | | | |
|---|---|---|---|---|
| | High Water. | | Low Water. | |
| Barking. | 1 foot from Surface. | 20 feet from Surface. | 1 foot from Surface. | 20 feet from Surface. |
| A. | 751· | 782· | 348· | 373· |
| B. | 751· | 784· | 376·6 | 384· |
| C. | 751· | 743· | 279· | 336· |
| D. | 737·6 | 753· | 273· | 312·5 |
| E. | 660· | 747· | 255· | 253· |
| Average of Position | 730· | 761· | 306· | 331·7 |
| Average of Position and Depth | 745· | | 318·8 | |
| Crossness. | | | | |
| A. | 860· | 933·5 | 396· | 399· |
| B. | 895· | 918·7 | 417· | 472· |
| C. | 905· | 932· | 482· | 535· |
| D. | 949· | 907· | 501· | 507· |
| E. | 954· | No sample. | 483· | 507· |
| Average of Position | 913. | 923· | 456· | 484· |
| Average of Position and Depth | 918· | | 470· | |
| Erith. | | | | |
| A. | 1019· | 1055· | 529· | 536· |
| B. | 1039· | 964· | 529· | 526· |
| C. | 1039· | 996· | 518· | 520·5 |
| D. | 1058· | 1072· | 518· | 526· |
| E. | 1067· | 1001· | 579· | 524· |
| Average of Position | 1044· | 1018· | 535· | 526· |
| Average of Position and Depth | 1031· | | 530· | |
| Gravesend. | | | | |
| A. | 1490· | 1512· | 1068· | 1064· |
| B. | 1471· | 1538· | 1039· | 1079· |
| C. | 1488· | 1512· | 1043· | 1066· |
| Average of Position | 1483· | 1521· | 1047· | 1070· |
| Average of Position and Depth | 1502· | | 1058· | |
| Southend. | | | | |
| ¼ mile from Pier, S.W. | 1912· | 1936· | 1770· | 1778· |
| 1 mile from Pier | 1920· | 1951· | 1786· | 1798· |
| 1¾ miles from Pier | 1936· | 1942· | 1764· | 1768· |
| 2 miles from Pier | 1912· | 1936· | 1711· | 1731· |
| 2 miles from Pier | 1893· | 1956· | 1717· | 1733· |
| Southend Pier (off end) | 1938· | 1946· | 1817· | 1810· |
| Average of Position | 1918· | 1944· | 1761· | 1769· |
| Average of Position and Depth | 1931· | | 1765 | |

*Note.*—When the depth of water was less than 20 feet, the samples were taken at the bottom.

*Neap Tide.*—September 22nd, 1882.

| | Chlorine Parts per 100,000. | | | |
|---|---|---|---|---|
| | High Water. | | Low Water. | |
| Teddington. | 1 foot from Surface. | 20 feet from Surface. | 1 foot from Surface. | 20 feet from Surface. |
| A. | 1·7 | 1·7 | 1·7 | 1·7 |
| B. | 1·7 | 1·7 | 1·8 | 1·8 |
| C. | 1·7 | 1·7 | 1·7 | 1·7 |
| D. | 1·7 | 1·7 | 1·8 | 1·7 |
| E. | 1·7 | 1·7 | 1·7 | 1·7 |
| Average of Position | 1·7 | 1·7 | 1·74 | 1·72 |
| Average of Position and Depth | 1·7 | | 1·73 | |
| Chiswick. | | | | |
| A. | 2·0 | 1·8 | 1·9 | 1·7 |
| B. | 1·95 | 1·9 | 1·8 | 1·8 |
| C. | 2·0 | 1·9 | 1·9 | 2·0 |
| Average of Position | 1·98 | 1·87 | 1·87 | 1·83 |
| Average of Position and Depth | 1·92 | | 1·85 | |

| | Chlorine Parts per 100,000. | | | |
|---|---|---|---|---|
| | High Water. | | Low Water. | |
| St. Paul's Pier. | 1 foot from Surface. | 20 feet from Surface. | 1 foot from Surface. | 20 feet from Surface. |
| A. | 81· | 88· | 2·2 | 2·4 |
| B. | 95· | 92· | 2· | 2·1 |
| C. | 85·5 | 94· | 2·7 | 3·3 |
| Average of Position | 87·2 | 91· | 2·3 | 2·6 |
| Average of Position and Depth | 89· | | 2·45 | |
| Teddington. | | | | |
| Samples marked F. | — | — | 1·7 | 1·7 |
| Deptford. | | | | |
| A. | 294· | 317· | 25·5 | 29· |
| B. | 304· | 318· | 24·5 | 24· |
| C. | 310· | 322· | 30· | 41· |
| Average of Position | 303· | 319· | 26·7 | 31· |
| Average of Position and Depth | 311· | | 28·8 | |
| North Woolwich. | | | | |
| A. | 578· | 594· | 176· | 160· |
| B. | 572· | 589· | 153· | 167· |
| C. | 574· | 578· | 162· | 152· |
| Average of Position | 575· | 587· | 164· | 160· |
| Average of Position and Depth | 581· | | 162· | |
| Barking. | | | | |
| A. | 656· | 632· | 268· | 303· |
| B. | 619· | 660· | 277· | 310· |
| C. | 628· | 648· | 274· | 310· |
| D. | 633· | 646· | 254· | 277· |
| E. | 645· | 620· | 262· | 268. |
| Average of Position | 636· | 641· | 267· | 294· |
| Average of Position and Depth | 638·5 | | 280· | |
| Crossness. | | | | |
| A. | 687· | 758· | 458· | 475· |
| B. | 698· | 746· | 440· | 456· |
| C. | 700· | 778· | 418· | 456· |
| D. | 794· | 807· | 410· | 440· |
| E. | 748· | 828· | 418· | 426· |
| Average of Position | 725· | 783· | 429· | 451· |
| Average of Position and Depth | 754· | | 440· | |
| Erith. | | | | |
| A. | 848· | 926· | 548· | 554· |
| B. | 883· | 906· | 544· | 548· |
| C. | 848· | 896· | 542· | 556· |
| D. | 888· | 902· | 550· | 564· |
| E. | 872· | 890· | 554· | 582· |
| Average of Position | 868· | 904· | 548· | 561· |
| Average of Position and Depth | 886· | | 555· | |
| Gravesend. | | | | |
| A. | 1280· | 1368· | 1054· | 1062· |
| B. | 1344· | 1376· | 1056· | 1064· |
| C. | 1392· | 1372· | 1064· | 1074· |
| Average of Position | 1332· | 1372· | 1058· | 1067· |
| Average of Position and Depth | 1352· | | 1062· | |
| Southend. | | | | |
| ¼ mile from Pier, S.W. | 1844· | 1910· | 1812· | 1828· |
| 1 mile from Pier, S.W. | 1876· | 1896· | 1810· | 1820· |
| 1¾ mile from Pier, S.W. | 1896· | 1910· | 1816· | 1816· |
| 2 miles from Pier, S.W. | 1880· | 1892· | 1804· | 1804· |
| Southend Pier (off end) | 1888· | 1884· | 1812· | 1836· |
| Average of Position | 1885· | 1898· | 1811· | 1821· |
| Average of Position and Depth | 1891· | | 1816· | |

## RESUMÉ.

| Collected September 14th 1882. | Chlorine per 100,000. Average of position and depth. | | Estimated per cent. Sea Water. | |
|---|---|---|---|---|
| | High Water. | Low Water. | High Water. | Low Water. |
| Teddington | 1·7 | 1·7 | — | — |
| Chiswick | 4·7 | 1·9 | — | — |
| St. Paul's Pier | 210·7 | 4·1 | 10·7 | ·2 |
| Deptford | 438· | 49· | 22·3 | 2·5 |
| North Woolwich | 671· | 180· | 34·2 | 9·2 |
| Barking | 745· | 319· | 37·9 | 16·3 |
| Crossness | 918· | 470· | 46·8 | 23·9 |
| Erith | 1031· | 530· | 52·5 | 27·0 |
| Gravesend | 1502 | 1058· | 76·6 | 54·0 |
| Southend | 1931· | 1765· | 98·5 | 90·0 |

| Collection of September 22nd 1882. | Average of position and depth. | | Estimated per centage of sea water. | |
|---|---|---|---|---|
| | High Water. | Low Water. | High Water. | Low Water. |
| Teddington | 1·7 | 1·73 | — | — |
| Chiswick | 1·92 | 1·85 | — | — |
| St. Paul's Pier | 89· | 2·45 | 4·5 | ·12 |
| Deptford | 311· | 28·8 | 15·8 | 1·47 |
| North Woolwich | 581· | 162· | 29·5 | 8·3 |
| Barking | 638· | 280· | 32·5 | 14·3 |
| Crossness | 754· | 440· | 38·4 | 22·4 |
| Erith | 886· | 555· | 45·2 | 28·3 |
| Gravesend | 1352· | 1062· | 68·9 | 54·2 |
| Southend | 1891· | 1816· | 96·4 | 92·6 |

| September 14th and 22nd compared. | High Water. | | Low Water. | |
|---|---|---|---|---|
| | September 14th. | September 22nd. | September 14th. | September 22nd. |
| Teddington | 1·7 | 1·7 | 1·7 | 1·73 |
| Chiswick | 4·7 | 1·92 | 1·9 | 1·85 |
| St. Paul's Pier | 210·7 | 89· | 4·1 | 2·45 |
| Deptford | 438· | 311· | 4·9 | 28·8 |
| North Woolwich | 671· | 581· | 180· | 162· |
| Barking | 745· | 638· | 319· | 280· |
| Crossness | 918· | 754· | 470· | 440· |
| Erith | 1031· | 886· | 530· | 555· |
| Gravesend | 1502· | 1352· | 1058· | 1062· |
| Southend | 1931· | 1891· | 1765· | 1816· |

The proportion of chlorine in sea water may be taken at 1961· parts in 100,000.

No. 1.

| Samples collected at St. Paul's Pier. | Chlorine in 100,000 parts. | |
|---|---|---|
| | 10 a.m. | 4 p.m. |
| 1882. | | |
| October 28 | 1·6 | 5·7 |
| „ 29 | 1·5 | 3·2 |
| „ 30 | 1·9 | 2·8 |
| „ 31 | 1·6 | 2·0 |
| November 1 | 1·5 | 2·2 |
| „ 2 | 1·7 | 2·3 |
| „ 3 | 2·0 | 1·7 |
| „ 4 | 1·8 | 1·7 |
| „ 5 | 1·8 | 1·8 |
| „ 6 | 2·3 | 2·0 |
| „ 7 | 2·2 | 1·7 |
| „ 8 | 1·8 | 1·8 |
| „ 9 | 2·0 | 2·0 |
| „ 10 | 2·0 | 2·0 |
| „ 11 | 1·8 | 2·4 |

| Samples collected at Half Tides at St. Paul's Pier. | | |
|---|---|---|
| October 28 | 12.30 p.m. | 4·7 |
| | 6.30 p.m. | 2·8 |
| November 1 | 8.40 a.m. | 2·5 |
| | 3.30 p.m. | 1·7 |
| November 4 | 12 noon | 1·8 |
| | 6.30 p.m. | 1·9 |
| November 7 | 8.40 a.m. | 2·0 |
| | 2.30 p.m. | 1·9 |
| November 11 | 12 noon | 2·6 |
| | 5.30 p.m. | 2.2 |

| Chlorine in Samples from Deptford Foreign Cattle Market. | 10 a.m. | 4 p.m. |
|---|---|---|
| October 28 | 1·8 | 30·8 |
| „ 29 | 2·3 | 10·3 |
| „ 30 | 1·95 | 5·1 |
| „ 31 | 2·8 | 3·3 |
| November 1 | 2·7 | 1·9 |
| „ 2 | 2·0 | 2·0 |
| „ 3 | 2·5 | 1·8 |
| „ 4 | 2·7 | 1·9 |
| „ 5 | 2·8 | 2·1 |
| „ 6 | 2·9 | 2·3 |
| „ 7 | 2·7 | 2·4 |
| „ 8 | 2·0 | 2·5 |
| „ 9 | 2·0 | 2·5 |
| „ 10 | 2·1 | 2·9 |
| „ 11 | 1·9 | 6·3 |

| Samples taken at Half Tides. | | |
|---|---|---|
| | 12.5 p.m. | 6.10 p.m. |
| October 28 | 12·4 | 11·9 |
| | 8.40 a.m. | 2.30 p.m. |
| November 1 | 2·2 | 1·7 |
| | 11.30 a.m. | 5.30 p.m. |
| „ 4 | 3·0 | 1·8 |
| | 9.0 a.m. | 3.50 p.m. |
| „ 7 | 2·0 | 2·6 |
| | 4.45 am | 5 p.m. |
| „ 11 | 2·6 | 4·5 |

| Samples collected at Erith. | Chlorine in 100,000. | |
|---|---|---|
| | 10 a.m. | 4 p.m. |
| 1882. | | |
| October 28 | 98·5 | 42·5 |
| „ 29 | 41·5 | 61·0 |
| „ 30 | 38·5 | 193·0 |
| „ 31 | 46·5 | 134·0 |
| November 1 | 30·5 | 57·0 |
| „ 2 | 38·0 | 58·5 |
| „ 3 | 23·5 | 17·0 |
| „ 4 | 67·5 | 9·5 |
| „ 5 | 145·0 | 13·5 |
| „ 6 | 149·5 | 15·5 |
| „ 7 | 132·5 | 32·0 |
| „ 8 | 166·5 | 46·5 |
| „ 9 | 45·5 | 64·0 |
| „ 10 | 55·0 | 130·0 |
| „ 11 | 54·0 | 213·5 |

| Samples collected at Half Tides at Erith. | | |
|---|---|---|
| October 28 | 11.30 a.m. | 274·0 |
| | 5 p.m. | 311·0 |
| November 1 | 8 a.m. | 76·0 |
| | 2 p.m. | 17·7 |
| November 4 | 10.30 a.m. | 52·5 |
| | 4.30 p.m. | 8·8 |
| November 7 | 8 a.m. | 20·0 |
| | 3 p.m. | 46·5 |
| November 11 | 11 a.m. | 63·5 |
| | 4.30 p.m. | 217·0 |

Samples collected 30th November 1882.
Chlorine in 100,000 parts.

| | High Water. | | Low Water. | |
|---|---|---|---|---|
| | Surface. | Deep. | Surface. | Deep. |
| Teddington | 1·7 | 1·7 | 1·7 | 1·7 |
| Chiswick | *2·2 | 1.7 | 1·7 | 1·8 |
| St. Paul's Pier | 2·8 | 2·8 | 2·0 | 1·8 |
| Deptford | 19·6 | 20·4 | 1·9 | 1·8 |
| North Woolwich | 118· | 118·5 | 3·4 | 2·8 |
| Barking | 147·5 | 157· | 5·6 | 4·4 |
| Crossness | 263· | 289· | 18·6 | 18·9 |
| Erith | 290· | 338·5 | 77· | 90·5 |
| Southend | 1770· | 1800· | 1460· | 1585· |

* Chiswick probably a Sewer at this point.
No Samples collected at Gravesend in this series.

*Prof. J. T. Vay, F.C.S.*

March 1883.

No. 2.

| | Samples of Sea Water from Margate. | Chlorine in 100,000. |
|---|---|---|
| 1882. | | |
| Oct. 29th - | High water, 12.40 p.m. - - | 1880· |
| | Low water, 7.29 p.m. - - | 1895· |
| „ 30th - | High water, 1.50 p.m. - - | 1930· |
| | High water, 1.33 a.m. - - | 1945· |
| | Low water. 8.10 p.m. - - | 1905· |
| „ 31st - | High water, 2.39 p.m. - - | 1910. |
| | Low water, 8.32 a.m. - - | 1890· |
| Nov. 1st - | High water, 3.23 p.m. - - | 1942.5 |
| | Low water, 9.16 a.m. - - | 1910· |
| „ 2nd - | High water, 4.15 p.m. - - | 1955· |
| | Low water, 10. 7 a.m. - - | 1935· |
| „ 3rd - | High water, 5. 2 p.m. - - | 1252·5 |
| | Low water, 11. 0 a.m. - - | 1942·5 |
| „ 4th - | High water, 6. 0 p.m. - - | 1940· |
| | Low water. 11.55 a.m. - - | 1927·5 |
| „ 5th - | High water, 7. 0 a.m. - - | 1910· |
| | Low water, 1.15 p.m. - - | 1927·5 |
| „ 6th - | High water, 8.15 a.m. - - | 1895· |
| | Low water, 2.35 p.m. - - | 1890· |
| „ 7th - | High water, 9.14 a.m. - - | 1920· |
| | Low water, 3.35 p.m. - - | 1905· |
| „ 8th - | High water, 9.59 a.m. - - | 1920· |
| | Low water, 4. 5 p.m. - - | 1887·5 |
| „ 9th - | High water, 10.38 a.m. - - | 1945· |
| | Low water, 5.15 p.m. - - | 1905· |
| „ 10th - | High water, 11.10 a.m. - - | 1910· |
| | Low water, 5.30 p.m. - - | 1880· |
| „ 11th - | High water, 11.45 a.m. - - | 1872·5 |
| | Low water, 6. 5 p.m. - - | 1825· |
| „ 12th - | High water, 6.25 a.m. - - | 1820· |

| Samples of Sea Water from Margate, 30th November 1882. | Chlorine in 100,000. |
|---|---|
| High water, 2.59 p.m., Wind north, blowing hard - - | 1770· |
| Low water, 9.10 p.m. Wind north, slight - - | 1737·5 |

Samples from the Nore.

| | | |
|---|---|---|
| 1882. | | |
| Sept. 24th - | 2.20 p.m., half-ebb. wind southerly, "Lion." | 1814· |
| „ „ - | Sea Reach, 3 p.m., wind S.S.E.. "Tern." | 1834· |
| „ 26th - | Abreast of Nore Light, half mile, 4.40 p.m., S. wind, "Penguin." | 1812· |
| „ 27th - | Nore, 2 p.m., calm tide, 2 hours ebb, "Hoboken." | 1556· |
| „ 28th - | Nore, half-flood, wind W.N.W., "Lion." | 1936· |
| „ 30th - | Nore, 2.50 p.m., S.S.W., high water, "Hoboken." | 1916· |
| Oct. 1st - | Nore abreast (?) 7.15 p.m., wind southerly, "Swallow." | 1852· |
| „ 2nd - | Nore, 1.45 p.m., half-flood, "Hoboken." | 1904· |
| „ 4th - | Nore abreast (?), 3 a.m., S.W., "Swallow." | 1860· |
| „ 4th - | Nore, Sea Reach, 6 a.m., wind W.S.W., "Tern." | 1792· |
| „ 8th - | Nore Stoint (?), 1 p.m. half ebb, "Lion." | 1880· |
| „ 12th - | Nore, 8 a.m., 1 hour after flood, "Lion." | 1878· |

No. 3.

Chlorine per 100,000 parts in samples taken from River Thames during Float Experiment, commencing 29th October, and continued day by day till 7th November, 1882.

Flood Tide.

| | | | |
|---|---|---|---|
| No. 1. - - | 1267·5 | No. 1a. - - | 1277·5 |
| 2. - - | 1295·0 | 2a. - - | 1282·5 |
| 3. - - | 1160·0 | 3a. - - | 1227·5 |
| 4. - - | 1080·0 | 4a. - - | 1215·0 |
| 5. - - | 232·0 | 5a. - - | 241·0 |
| 6. - - | 253·5 | 6a. - - | 248·5 |
| 7. - - | 187·5 | 7a. - - | 200·0 |
| 8. - - | 117·5 | 8a. - - | 134·5 |
| 9. - - | 4·4 | 9a. - - | 4·4 |
| 10. - - | 3·6 | 10a. - - | 3·7 |
| 11. - - | 3·8 | 11a. - - | 3·8 |
| 12. - - | 3·6 | 12a. - - | 3·7 |
| 13. - - | 1·7 | 13a. - - | 1·6 |
| 14. - - | 1·5 | 14a. - - | 1·7 |
| 15. - - | 1·6 | 15a. - - | 1·7 |
| 16. - - | 1·7 | 16a. - - | 1·6 |
| 17. - - | 1·5 | 17a. - - | 1·7 |
| 18. - - | 1·6 | 18a. - - | 1·5 |
| 19. - - | 1·5 | 13a. - - | 1·7 |
| 20. - - | 1·7 | 20a. - - | 1·6 |
| 21. - - | 1·6 | 21a. - - | 1·5 |
| 22. - - | 1·6 | 22a. - - | 1·6 |

Ebb Tide.

| | | | |
|---|---|---|---|
| No. 23. - - | 1·6 | No. 23a. - - | 1·8 |
| 24. - - | 1·6 | 24a. - - | 1·6 |
| 25. - - | 2·4 | 25a. - - | 1·7 |
| 26. - - | 1·9 | 26a. - - | 1·8 |
| 27. - - | 2·1 | 27a. - - | 2·1 |
| 28. - - | 2·8 | 28a. - - | 2·7 |
| 29. - - | 3·5 | 29a. - - | 3·6 |
| 30. - - | 39·2 | 30a. - - | 50·0 |
| 31. - - | 108·5 | 31a. - - | 119·0 |
| 32. - - | 206·5 | 32a. - - | 208·0 |
| 33. - - | 302·5 | 33a. - - | 343·0 |
| 34. - - | 937·5 | 34a. - - | 1005·0 |
| 35. - - | 1025·0 | 35a. - - | 1125·0 |
| 36. - - | 1167·5 | 36a. - - | 1227·5 |
| 37. - - | 1295·0 | 37a. - - | 1365·0 |

No. 4.

| | Samples from Grays. Collected 22nd December 1882. | Chlorine in 100,000. |
|---|---|---|
| 1 | "Green Man and Bell," 11.30 a.m. Well 20 feet deep. | 14·0 |
| 2 | "The Dell." Mr. . Well 100 feet deep. Short way out Grays. 12.30 p.m. | 2·5 |
| 3 | Sockets Heath Cottage. Well 104 feet deep. 1.30 p.m. | 3·6 |
| 4 | The College, Little Thurrock. Well 90 feet deep. 2.15 p.m. | 13·0 |
| 5 | Brewery, Grays. Half tide, 10.15 a.m. | 9·7 |
| 6 | Ditto High tide, 12 noon | 9·7 |
| 7 | Ditto Low water, 3.45 p.m. | 9·7 |
| 8 | South Essex Waterworks. Half tide, 9 a.m. | 13·3 |
| 9 | Ditto High water, 11.15 a.m. | 13·6 |
| 10 | Ditto Low water, 3.45 p.m. | 13·4 |
| 11 | Grays Chalk Quarries. Half ebb, 9 a.m. | 3·9 |
| 12 | Ditto High water, 12 noon (?) | 4·2 |
| 13 | Ditto Low water, 3.50 p.m. | 4·2 |
| 14 | River Thames off "Exmouth." Half tide, 9 a.m. | 507·5 |
| 15 | Ditto High water, 11 a.m. | 635·0 |
| 16 | Ditto Low water, 3.45 p.m. | 475·0 |

| | Samples from Wells at Erith. Taken December 30th, 1882. | |
|---|---|---|
| 11.30 a.m. | Pump well near the river, just above Beadle's Coal Wharf. | 3·8 |
| 11.30 a.m. | Pier head (river) at low water - | 40·5 |
| 12.30 p.m. | Well at 21, Pier Road, about 120 feet deep. | 3·6 |
| 12.35 p.m. | Well at Crown Cottages (?), Cross Street, leading out of Pier Street. Well very deep. | 10·8 |
| 1.30 p.m. | Well at Crayford Road, North End Cottages, about 1¼ to 1½ miles from pier. Well about 120 feet deep. | 5·6 |
| 1.40 p.m. | Well in same road, opposite side, about 200 to 300 north-east, about same depth as last. | 1·4 |

(*Witness.*) The first table is a table of samples collected on September the 14th and September the 22nd. I do not know whether the Commission know how these samples were collected, because if that has not been described it certainly ought to be described now.

11,289. (*Chairman.*) You did not collect them?—No, I did not collect them; they were merely brought to me.

11,290. Did you determine the mode in which they should be taken?—No.

11,291. Do you approve of the mode in which they were taken?—Yes; but unless that mode has been described to the Commission it should be described.

(*Chairman.*) We have not had the witness who took the samples. Dr. Tidy took some of the samples himself.

(*Mr. Bidder.*) As I understand Professor Way, he is not at all responsible for the taking of the samples; certain samples were brought to him labelled.

(*Mr. Balfour Browne.*) If it is necessary we can prove the taking of every sample.

(*Mr. Bidder.*) It is necessary.

(*Mr. Balfour Browne.*) What I want to bring before the Commission now is the method of taking the samples by description.

(*Mr. Bidder.*) But that will not prove the samples, because Professor Way did not take them.

(*Chairman.*) He is going to say that, assuming the samples were taken in the way he is going to describe, that was the proper way of taking them.

(*Mr. Bidder.*) But did he give the instructions as to the way in which they should be taken.

11,292. (*Chairman.*) No he did not. (*To the witness.*) You were told how the samples were taken?—Yes, it was in rather a lengthy way, but it ought to be given, if the Commission are to understand the value of the tables.

11,293. Will you give us the way in which you were informed the samples were taken?—I will; in fact I was informed of it by Dr. Collingridge, who had the responsibility of seeing that the samples were taken properly, but Mr. Balfour Browne will understand that I did not know whether this information had been given yet.

(*Mr. Balfour Browne.*) I do not think that the method of taking the samples has been given.

(*Witness.*) Do you propose to give it?

(*Mr. Balfour Browne.*) I thought you said it was important it should be given.

(*Chairman.*) Will you state how it was described to you that they were taken.

(*Mr. Bidder.*) But that is not evidence. The person who really took the sample must describe how it was taken, but what you put is a very legitimate question. If that sample was taken in such a way, was that properly taken.

(*Chairman.*) Quite so, and the witness will then say that if the samples were taken in such and such a manner, that was a very proper manner in which to take them.

11,294. (*Mr. Balfour Browne.*) (*To the witness.*) Will you describe how the samples were taken?—You will notice that in the first half of the first sheet, the localities, Teddington, Chiswick, St. Paul's Pier, and so on are named; those were 10 stations upon the river that were selected as places at which to take the samples, the object being to ascertain how far, and under what circumstances, the sea water, as indicated by the chlorine, went up the river. These 10 stations are from Teddington to Southend; at Teddington, as a matter of course, the water flowing over the weir would not be subject to tidal influence, but the sample taken at Teddington was below the weir, and therefore it is the last point of the river to which sea water could have access. The samples were taken, in some cases three samples, and in other cases five samples, at certain equal distances across the river; the object being to ascertain whether there was any difference in the flow of the tidal water. They were also taken at one foot from the surface, and in some cases as near the bottom as possible, and in other cases at 20 feet deep. In the upper reaches, at low water especially, there was not enough water to take them at 20 feet deep, but wherever 20 feet depth of water could be obtained a sample was taken at 20 feet. Then a sample was taken on high tide and low tide, so that wherever there are five stations across the river, we have 20 samples at that particular spot, 10 of which were taken at high tide and 10 at low tide. As I say, I have no responsibility and equally no credit for the method of collection, but the object is obviously to avoid any differences which were not due to the motion in the river from its source.

11,295. (*Chairman.*) You think that the manner of collection is correct?—I think it is admirable; it involved an amazing deal of trouble, but at the same time there can be no mistake as to the result.

11,296. (*Mr. Balfour Browne.*) Now just taking Teddington first, that first determination 1·8 represents the result of five samples, does it not?—No; this is exactly why a full description of our method is necessary, that represents one sample only.

11,297. I see the whole of the samples are put under each other?—Yes.

11,298. So that there was a separate analysis for each sample?—There was a separate analysis for each sample.

11,299. I think it may be as well to point out that the letter "A." always begins upon the south shore of the river?—Yes.

11,300. And that the other letters stretch across the river to the north shore?—Yes.

11,301. (*Chairman.*) The blue printed table which is taken from Mr. Baldwin Latham's pamphlet, gives the net results of your analysis, does it not?—Yes, only I thought it necessary that you should know how the net results had been got out; indeed it is absolutely necessary, because it sweeps away, as we believe, the possibility of error due to difference of position in the river, and depth from which the sample was taken in the river.

11,302. (*Chairman.*) Are there any further remarks that you wish to make with respect to the details?—No, I think not, except that the second table called "Resumé," is the result of the averages of these others.

11,303. (*Mr. Balfour Browne.*) But before we get to the second table, upon this first table, there are two sets of determinations in relation to a spring tide upon the 14th of September, and a neap tide upon the 22nd?—Yes.

(*Sir John Coode.*) All these are in the blue paper.

11,304. (*Mr. Balfour Browne.*) But there is the 30th of November 1882. (*To the witness.*) Have you the set of determinations for that?—I have; that has been handed in with the others.

11,305. Amongst those documents that you have handed in, there are various other tables, No. 1, No. 2, No. 3. and No. 4; what are those?—Those are other analyses of water for chlorine which were or have been used, I dare say, in this inquiry.

11,306. Those analyses were made by you from the water supplied in the same way as you have described?—Yes.

11,307. Will you now state briefly the evidence you are prepared to give?—First of all I cannot expect, nor would it be right, that the method in which this analysis has been made should pass without animadversion, or at all events inquiry; therefore I wish to say something about that. Now, as a rule, the analysis for chlorine is one of the easiest things imaginable, and I do not say it is otherwise than easy in this case; but it is not as a rule that chemists have to deal with sea water, that is to say, with water containing very large quantities of chlorine. The analyses of sea water have been, perhaps, the most neglected of all kinds of water. Now there are two methods of analysis for chlorine, one the old or gravimetric method, in which the chlorine is collected as chloride of silver and weighed; another method is the method of determining it by volume, that is to say by a colour test—that is known as the volumetric method; the one is much easier and takes up much less time than the other, and it is natural in cases where a large number of analyses were to be made that one would take a method which would enable him to get more readily the results, consequently the volumetric method was taken; but I found that as there was so much work to do, it was necessary one should be quite safe of one's facts before one commenced, and I found in determining the salt in sea water, or water at Southend, or anywhere near the sea, where large quantities of salt were, that the ordinary method in the first place did not give correct results as usually

*Prof. J. T. Way, F.C.S.*

7 March 1883.

worked—that is to say, there were some 2 or 3 per cent. of difference in the chlorine in the actual result, when the usual strength of silver test was employed.

11,308. (*Prof. Williamson.*) Are you now speaking of the gravimetric method?—I am speaking now of the volumetric method, although even in the gravimetric method the determination of large quantities is liable to considerable error owing to some difficulty of measuring.

11,309. Have you pursued one method all through?—I have checked them; these are mainly made by the volumetric method.

11,310. (*Sir John Coode.*) But you have taken every step to satisfy yourself of the accuracy of the result?—Yes. I do not wish to give a lecture on chemistry, but I say now, as the result might perhaps be questioned when one was not here to explain it, that it is extremely difficult to get accurate results within 1 or 2 per cent. of the whole chlorine from these waters, which contain large quantities of salt; but then as a matter of course, where larger quantities of salt are, the less the little variations matter. The chemical members of the Commission will know, of course, that we cannot take large quantities of a solution of salt for this purpose, but we must have a small quantity, and we can only get that small quantity by dilution and sub-measurement, not by taking very minute quantities; it is not possible to get them near enough. I believe these results are within 1 or 1½ per cent. of the total chlorine present, that is, of the total common salt present, so that a quantity which would stand in these tables as 1,000, for instance, might be 1,010, or it might be 990; but that would make no real difference, and that is my object, to show that that difference is not material.

11,311. (*Mr. Balfour Browne.*) Have you any further remark to make with regard to the method of making the analyses?—I think that is all that it is necessary to say.

11,312. Now I will ask you one question with regard to what fell from another witness. These determinations show the quantity of chlorine in the cross-section taken across the river?—Yes.

11,313. And you find, do you not, that the quantity of chlorine varies very little either across the river, or by reason of depth?—No; and that is very important. I have omitted to say that there is very little difference in the samples as taken across the river, or as taken at 1 foot from the surface, or taken deep.

11,314. (*Sir John Coode.*) Which the tables show?—Yes, which the tables show; and this resumé is deduced from these tables, the consequence is that the resumé may fairly be taken as proving the state of the river.

11,315. (*Mr. Balfour Browne.*) Is there a greater difference between the samples taken at the surface and those taken 20 feet down?—There is a greater difference; it is not a great difference, but it is a more general difference.

11,316. This resumé of yours, which you have handed in, and which is before the Commission, is, I think, the mean of all the experiments that were shown upon the other tables?—No, it is the mean of the experiments shown upon the first table.

11,317. You have a similar series of observations as to the 30th of November, except that on the 30th of November they were not taken across the river because there had been found to be no difference arise from taking them across the river?—Yes, they were only taken at one point upon the river instead of being taken across the river; but they were taken even in that case shallow and deep.

11,318. (*Mr. Bidder.*) It is not quite correct to say that there was no difference, because the tables show that there were considerable differences?—Yes, there were differences, but the differences were so much less than the differences at the different stations that it was not worth while taking them in so many places.

11,319. You cannot tell us, I suppose, what part of the river they were taken from upon the last occasion?—No, except from general knowledge.

(*Sir John Coode.*) Would not those differences be accounted for by the quantity of fresh water in the river?

(*Mr. Bidder.*) No doubt that accounts for there being less chlorine generally, but that is not the point.

11,320. (*Dr. Stevenson.*) Would you allow me to direct your attention to one matter. You heard the question I put to the previous witness with regard to the decomposition of urea. I believe you have made some experiments upon that subject, and before you come next before us you would perhaps be able to give us some information as to the rate at which urea decomposes in sewage?—It decomposes at a very great pace. In London sewage you can never find urea.

11,321. You have never found it?—No.

11,322. (*Mr. Bidder.*) You mean it is all gone before it gets out of the sewers?—Yes, but urea is not carbonate of ammonia you will recollect.

11,323. (*Dr. de Chaumont.*) Have you made any experiments as to how soon putrefaction sets in in sewage?—I cannot say that; not to give any definite idea.

11,324. (*Sir John Coode.*) The urea disappears as urea, but it takes up some other form?—It becomes carbonate of ammonia; but what I mean to say is that the urea is so evanescent that you must never expect to find it in sewage. Urea is one of the most easily changed matters imaginable; by any organic matter passing into it, it is changed almost immediately.

(*Mr. Balfour Browne.*) It will be understood that Tables 1, 2, 3, and 4 are proved by Professor Way.

*Mr. Bidder* stated that he had no questions to ask the witness at present in cross-examination.

The witness withdrew.

Professor Charles William Heaton, F.I.C., F.C.S., called in and examined.

*Prof. C. W. Heaton, F.I.C., F.C.S.*

11,325. (*Mr. Lumley Smith.*) I believe you are a Fellow of the Institute of Chemistry?—I am.

11,326. And a Fellow of the Chemical Society?—Yes.

11,327. You are also Lecturer on Chemistry at the Charing Cross Hospital?—I am.

11,328. And you are also one of the Examiners in Chemistry to the Royal College of Physicians?—Yes.

11,329. I believe you reside in the neighbourhood of Erith?—Yes, I do.

11,330. Are you often on the river?—Yes.

11,331. How long have you known the river in that way?—I have known the river, to a certain extent, for the last 20 years, but it is only in the last few years that I have been frequently upon the river.

11,332. (*Chairman.*) Within what time?—I should say within the last five or six years I have been sailing occasionally upon it.

11,333. (*Sir John Coode.*) How near is your house to the river?—About a mile, or a mile and a half. I am in Erith parish, but not in the immediate neighbourhood of the river.

11,334. (*Mr. Lumley Smith.*) Now I will ask you generally, have you at any time found anything unpleasant in the condition of the river?—Yes, I have observed disagreeable smells.

11,335. Is that at any particular time, or all the year round?—In hot weather only.

11,336. Where do the smells come from?—I have distinctly smelt a disagreeable smell from the river, but still more frequently from the mud; and certainly from both in hot weather.

11,337. Have you found that increase or decrease of late years?—I cannot say for certain upon that point. I believe Professor Tuson is more experienced than I am upon the river, and he will be able to speak to that.

11,338. In cold weather can you at any time detect smells?—Yes, when very near the outfalls.

11,339. How far off from the outfall?—I have smelt it even in cold weather I think I may say safely at a distance of one mile when the wind has been from that direction.

11,340. But in very hot weather how far have you detected the smell?—In very hot weather I have smelt the smell of the water miles away. It has come down upon the wind.

11,341. It is not a smell perceptible upon the water only, but a smell that has come down upon the wind itself?—Yes.

11,342. (*Sir John Coode.*) Did you smell it last summer?—I smelt it very slightly.

11,343. Was that on account of the wetness of the weather and the cold?—Yes.

11,344. (*Mr. Lumley Smith.*) Now you smell these smells in cold weather?—Yes, upon the river.

11,345. Do you detect them upon the shore?—No, I cannot say that I can detect them there.

11,346. (*Mr. Bidder.*) When you say you smelt the river miles away, what do you mean; do you mean miles away from the river?—No, I mean miles from the outfall.

11,347. (*Mr. Lumley Smith.*) What are the prevailing winds at Erith that would carry the smells from the outfall itself?—The winds that would carry the smell you would see, I think, by the map, are north, north-west, and north-east, but not the southerly winds, or the south-westerly winds.

11,348. The former are usually cold winds?—Yes, I think they are.

11,349. So that at the time when the smell would come from the outfall would be the time when the weather is cool and the winds are cold?—I think so.

11,350. Those winds which prevail in the summer months would mostly blow the other way. Now you have not only given attention generally in this way to the water, but you have made a series of experiments upon the water?—Yes, with Professor Tuson.

11,351. I believe he also lives near Erith, does he not?—Yes, he does.

11,352. Will you tell us generally, before I come to details, the nature of the experiments you have made with the water?—We have made a certain number of analyses of the water, taking special points which seemed to us to be likely to be valuable. Of course our experiments have been by no means so extensive as those of the chemists who have given evidence, but we tender them because we think there have been some points of importance proved by them.

11,353. (*Sir John Coode.*) When you say "of "importance," you mean with regard to the composition of the water?—Yes, I think so.

11,354. (*Mr. Lumley Smith.*) You have taken samples, as I understand?—Yes, we have taken samples ourselves.

11,355. And you have tested the samples?—Yes.

11,356. For what purposes, and in what way have you tested the samples; first of all have you tested them for the purpose of finding out what component parts there are in them, what are the things you have tested for?—We have tested for certain constituents.

11,357. Will you tell us the particular constituents for which you tested?—Those which appeared to us to be most important are two in number, first the examination of what is called albumenoid ammonia, and, secondly, the determination of dissolved oxygen.

11,358. Those are the two important ones?—I do not say that they are the only important ones, but we regarded them as very important for our special purpose.

11,359. You have tested for those two things, have you tested for anything else?—Yes for certain other constituents; we have made a certain number of determinations of nitrates on special occasions.

11,360. Will you tell us, first of all generally, between what dates you made your experiments?—The experiments began in July, and were made at intervals as the time at our command allowed through the greater part of the rest of the year.

11,361. I believe you have prepared some tables of which you have a copy before you?—Yes, this is a table (*producing the same*), giving three constituents only, and of those only one appears to me to be of special importance to the Commission, one of them is a determination of the free ammonia. You have heard so much about free ammonia, that I apprehend the Commission would scarcely care to have more evidence upon that matter: there is ammonia in the river, and I daresay you do not care to hear more about it, the figures are very irregular, and I do not profess to found much upon them; they tend to show that the river is polluted, and polluted with sewage, but I do not apprehend that that will be doubted.

11,362. (*Sir John Coode.*) It is a question of extent?—Yes, I do not pretend to be able to speak to the extent of the pollution from ammonia. I think our determinations about the albumenoid ammonia do give results of some interest. This table, which I will hand in, shows the parts per 100,000 of free ammonia, oxygen absorbed, and albumenoid ammonia.

(*The same were handed in, and were as follows.*)

*Prof. C. W. Heaton, F.I.C., F.C.S.*

7 March 1883.

## THAMES POLLUTION.

| Number of Sample. | Date (1882.) | Where taken. | I. Parts of Free Ammonia in 100,000 of Water. | | | | II. Parts of Oxygen absorbed in 100,000 of Water. | | | | III. Parts of Albumenoid Ammonia in 100,000 of Water. | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | High Water. | Low Water. | Flood. | Ebb. | High Water. | Low Water. | Flood. | Ebb. | High Water. | Low Water. | Flood. | Ebb. | |
| 1 | July 8 | Off Purfleet: in tideway. | — | — | ·0264 | — | — | — | ·6280 | — | — | — | ·0921 | — | Water very black. |
| 2 | Do. | About half a mile below Crossness: in tideway. | ·0534 | — | — | — | ·3000 | — | — | — | ·0434 | — | — | — | Much seaweed. |
| 3 | Do. | Twenty yards above Crossness Outfall; half an hour before high water: close to South Shore. | ·2789 (Not included in average.) | — | — | — | 2·200 (Not included in average.) | — | — | — | ·2785 (Not included in average.) | — | — | — | Sewage distinctly seen to be flowing up stream; bad smell in air; one engine at work at pumping station. |
| 4 | July 17 | Off Crossness: midstream. | ·0494 | — | — | — | ·3160 | — | — | — | ·0538 | — | — | — | Engine at pumping station not at work. |
| 5 | Do. | One mile above Barking Outfall: midstream | ·0680 | — | — | — | ·3640 | — | — | — | ·0688 | — | — | — | |
| 6 | Do. | Off Crossness: same place as No. 4, but about two hours later. | — | — | — | ·0549 | — | — | — | ·5320 | — | — | — | ·1183 | In full stream of sewage from Barking, but not from Crossness; foul smell in air from north shore. |
| 7 | Do. | Between Crossfield's and Belvedere Guano Company's Works: midstream. | — | — | — | ·0070 | — | — | — | ·4800 | — | — | — | ·1140 | In line of Barking, but out of line of Crossness sewage. |
| 8 | Do. | Between Corinthian Yacht Club and Post on North Shore: midstream. | — | — | — | ·0324 | — | — | — | ·4880 | — | — | — | ·0800 | In line of sewage from both outfalls. |
| 9 | July 25 | Same as No. 8. - | — | — | — | ·0875 | — | — | — | ·3914 | — | — | — | ·0518 | |
| 10 | Do. | Off the "*Cornwall*": midstream. | — | — | — | ·0264 | — | — | — | ·3217 | — | — | — | ·0399 | |
| 11 | Do. | Off Greenhithe: between the "*Worcester*" and the "*Shaftesbury.*" | — | ·0320 | — | — | — | ·3280 | — | — | — | ·0462 | — | — | |
| 12 | Do. | Same as No. 11 - | — | — | ·0050 | — | — | — | ·4380 | — | — | — | ·0804 | — | |
| 13 | Do. | Same as No. 10 - | — | — | ·0180 | — | — | — | ·2800 | — | — | — | ·0319 | — | |
| 14 | Do. | Same as No. 8 - | — | — | ·0044 | — | — | — | ·3960 | — | — | — | ·0843 | — | |
| 15 | August 1 | Off Corinthian Yacht Club. | — | ·1955 | — | — | — | ·4400 | — | — | — | ·1039 | — | — | Middle of eddy, near South Shore-water of brown colour and smelt strongly of sewage. |
| 16 | Do. | Off Corinthian Yacht Club: between edge of eddy and North Shore. | — | ·1544 | — | — | — | ·4357 | — | — | — | ·0889 | — | — | Colour not quite so bad, and smelt similar to, but not nearly so bad, as No. 15. |
| 17 | Do. | Same as No. 16: in heart of tide. | — | — | ·1188 | — | — | — | ·4960 | — | — | — | ·1617 | — | Colour lighter than No. 16; odour slight, but distinctly offensive. |
| 18 | Do. | Same as No. 16: midstream. | ·0030 | — | — | — | ·4960 | — | — | — | ·1044 | — | — | — | Colour much better than last sample; no bad smell. |
| 19 | Do. | Same as No. 16: heart of tide. | — | — | — | ·0274 | — | — | — | ·2400 | — | — | — | ·0419 | Colour slight; no bad smell. |
| 20 | Do. | Same as No. 19 - | — | — | — | ·1272 | — | — | — | ·4800 | — | — | — | ·0949 | Colour dark brown; odour not bad. |
| 21 | Do. | Same as No. 19 - | — | — | — | ·0051 | — | — | — | ·4800 | — | — | — | ·1119 | Colour dark brown; odour sewage-like; rather bad. |
| 22 | August 7 | About 1 mile below Jenningtree Point, and about 200 yards from South Shore. | — | — | — | ·0219 | — | — | — | ·5360 | — | — | — | ·1487 | In strong eddy; smell of sewage in water. |
| 23 | Do. | Off Jenningtree Point: midstream: heart of tide. | — | — | — | ·1979 | — | — | — | ·4760 | — | — | — | ·1009 | Sewage smell in water. |
| 24 | Do. | Just below Little Cold Harbour Point: about 200 yards from North Shore. | — | — | — | ·0424 | — | — | — | ·5400 | — | — | — | ·1827 | Very dirty; sewage smell. |

| Number of Sample | Date (1882.) | Where taken. | I. Parts of Free Ammonia in 100,000 of Water. | | | | II. Parts of Oxygen absorbed in 100,000 of Water. | | | | III. Parts of Albumenoid Ammonia in 100,000 of Water. | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | High Water. | Low Water. | Flood. | Ebb. | High Water. | Low Water. | Flood. | Ebb. | High Water. | Low Water. | Flood. | Ebb. | |
| 25 | August 7 | Above Half-way Point, about 100 yards below Powder Magazine, and about 75 yards from South Shore. | — | — | — | ·0030 | — | — | — | ·5960 | — | — | — | ·2080 | |
| 26 | Do. | Off mouth of Albert Dock. | — | ·0223 | — | — | — | ·4960 | — | — | — | ·103 | — | — | Slight odour |
| 27 | Do. | Abreast (within 30 yards) of the Pier of Beckton Gasworks. | — | ·0143 | — | — | — | ·4680 | — | — | — | ·1880 | — | — | |
| 28 | Do. | Same place as No. 25. | — | — | ·0296 | — | — | — | ·6160 | — | — | — | ·1389 | — | |
| 29 | Do. | Same place as No. 22. | — | — | ·0689 | — | — | — | ·4560 | — | — | — | ·1024 | — | |
| 30 | Do. | Same place as No. 23. | — | — | ·0180 | — | — | — | ·5760 | — | — | — | ·2557 | — | In wake of large steamer. |
| 31 | Do. | Same place as No. 24. | — | — | ·1413 | — | — | — | ·4600 | — | — | — | ·1413 | — | |
| 41 | Sept. 18 | Midway between Corinthian Club and Post on North Shore. | ·0550 | — | — | — | ·6200 | — | — | — | ·0324 | — | — | — | No smell. |
| 42 | Do. | Same place as No. 41. | — | — | — | ·2650 | — | — | — | ·6814 | — | — | — | .0170 | No smell. |
| 43 | October 8 | Just off Curtis and Harvey's Powder Magazine. | — | — | — | ·2900 | — | — | — | — | — | — | — | ·0724 | In heart of sewage stream from Crossness. |
| 45 | „ 11 | Mid-river C.Y.C. - | ·1560 | — | — | — | — | — | — | — | ·0520 | — | — | — | |
| Average of all the samples, except No. 3. | | | ·0641 | ·0837 | ·0478 | ·0913 | ·4192 | ·4335 | ·4829 | ·4802 | ·0591 | ·1050 | ·1210 | ·0952 | |
| Averages in sewage area during all times of tide. | | | ·0671 | | | | ·4539 | | | | ·0950 | | | | |
| Averages—excluding exceptional samples Nos. 30, 41, and 42. | | | ·0434 | ·0837 | ·0515 | ·0785 | ·3690 | ·4335 | ·4712 | ·4648 | ·0645 | ·1050 | ·1041 | ·1012 | |
| Do. in sewage area during all times of tide. | | | ·0643 | | | | ·4346 | | | | ·0937. | | | | |
| 35 | Sept. 9 | Sea Reach: off Hole Haven. | — | ·0150 | — | — | — | ·3200 | — | — | — | ·0155 | — | — | |
| 36 | Do. | Do. | ·0044 | — | — | — | ·5760 | — | — | — | ·0102 | — | — | — | Water very phosphorescent. |
| 47 | Oct. 12 | Off Charing Cross Pier. | — | ·0647 | — | — | — | — | — | — | — | ·0233 | — | — | |
| 23 | August 8 | Just above Kingston: mid-stream. | — | — | — | — | — | — | — | — | — | — | — | — | Free Ammonia, ·0150; Oxygen absorbed, ·1520; Albumenoid Ammonia, ·0273. |

* There is no evidence as to the collection of this sample.

11,363. Now passing to the subject of the albumenoid ammonia, have you any remarks to make with regard to the samples that you took?—Yes; may I explain why we use that particular method.

11,364. Will you proceed to do so?—We use that method because we think that it does give evidence with regard to the organic matter capable of putrefaction that is present in the water. The bad smells that we have observed are in our opinion due to the putrefaction of nitrogenous matter in the water, and for that purpose it was desirable to get some kind of measure of the quantity of such albumenoid matter. Now the organic nitrogen determination is of the greatest value, but it is to a certain extent reduced in value in an inquiry like this, by the fact that sea water contains much organic nitrogen. Now it is perfectly well known to us, as it is I believe to all other chemists, that the albumenoid ammonia estimation only represents some fraction of the nitrogenous putrefialbe organic matter.

11,365. (*Prof. Williamson.*) You mean the determination by permanganate?—Yes; but I believe it is pretty well agreed that in a river like the Thames albumenoid ammonia does come from nitrogenous organic matter of some kind. Certainly the experience of every chemist who has worked by this method is that you get much albumenoid ammonia from bad polluted water and very much less or none at all from unpolluted water.

11,366. (*Chairman.*) Why do you say in "a "river like the Thames"?—Because I can imagine that the test would have a different value if it applied to other rivers, as for instance, a river highly impregnated with peat. I have no experience of how it would happen elsewhere, because our experiment only applied to the Thames, and I should not like to give it as to other rivers. In the river Thames it appears to me that the albumenoid ammonia must come from nitrogenous organic matter capable of putrefaction.

11,367. (*Mr. Lumley Smith.*) Did you use for the purpose of your experiment filtered or unfiltered water?—Unfiltered water.

11,368. Will you explain why you did so?—Because

*Prof. C. W. Heaton, F.I.C., F.C.S.*

7 March 1883.

we believe that the river smell is due to putrefaction. Now, the nitrogenous organic matter in the water would be partly in solution and partly in suspension; it appeared to us that it did not matter in which condition it was; the question was whether it would putrefy and smell, and as the water was unfiltered we thought that it would be better to make our experiments in the water as it stood, so that they should represent, as far as they were able to do, the actual condition of the river. Whatever albumenoid ammonia we got must have been derived from some quantity of nitrogenous matter; we cannot say exactly how much.

11,369. What results have you got?—We got, in the first place, very considerable quantities of albumenoid ammonia throughout the area, which we particularly examined; that is to say, from Woolwich to Greenhithe, and we found considerable quantities—very considerable quantities, I may say—at all times of the tide; in fact, the mean results of our determinations in this way do not indicate any material difference between the composition of the water at different times of the tide except at high water, when there is distinctly less.

11,370. (*Chairman.*) For about how long before and after high water?—At various times; we have taken determinations at high water, low water, flood, and ebb; some exactly at high water and some exactly at low water; some taken at the flood, and some at various times in the ebb. I think we examined about 40 samples in that way.

11,371. (*Sir John Coode.*) You said you found the greatest difference at high water?—We found, as we expected, the least proportion at high water.

11,372. (*Chairman.*) But how much upon either side of the top of the tide?—The quantities found varied very much indeed, and I suppose that was due to a very great extent to our using unfiltered water; we found very great differences throughout the experiment.

11,373. (*Sir John Coode.*) But you would hardly use anything but unfiltered water, otherwise what would be the value of the experiment?—We thought it better to use unfiltered water, but other chemists we believe prefer to use filtered water.

11,374. (*Prof. Williamson.*) You use solely the permangate process for the determination of the albumenoid ammonia matter?—Yes; first distilling with sodium carbonate until the liquid was quite free from ammonia.

11,375. (*Mr. Lumley Smith.*) Upon the table you have handed in, Nos. 41 and 42 have been accidentally filtered?—Yes.

11,376. And therefore they are excluded from the average?—Yes; may we add that we excluded two other samples, one because the water was taken so near the outfall that it was more like sewage than water, and another, which contained a very large quantity of albumenoid ammonia, because it was taken in the wake of a very large steamer which stirred up the mud.

11,377. (*Sir John Coode.*) Where were the samples taken that were taken near the outfalls?—They were taken just off the outfalls.

11,378. That expression is rather vague?—Then I will say in the middle of the river just about opposite the outfall; but you will find that the variations in quantity are very great. I do not desire to overstate the evidence in any way, but we say we find very large quantities of albumenoid ammonia.

11,379. (*Mr. Lumley Smith.*) Will you read the averages?—I have taken them in parts per 100,000: high water, ·0645; low water, ·1050; at flood, ·1041, and at ebb, ·1012; those are taken after the exclusions which I have mentioned, which, for the reasons I have stated, it seemed unfair to include. The average of those numbers, including high water, is ·0937.

11,380. Can you compare that with observations made elsewhere, and will you give them?—Yes; there are very few; but we think it will hardly be denied that they represent the probabilities of the case.

11,381. (*Sir John Coode.*) By ·0937 you mean practically one millionth?—Yes; then we collected two samples in Sea Reach, one exactly at high water and the other at low water; the high water sample gave us ·0102 on the unfiltered water, and the low water sample gave us ·0154. We therefore succeeded in extracting from the water in our district about seven times the quantity of albumenoid ammonia that we could get from Sea Reach; that is what it comes to; but then we do not pin ourselves to those figures exactly. We made also another analysis of water at Charing Cross about the same time, which gave us at low water ·0233.

11,382. (*Mr. Lumley Smith.*) I understand you to say that you do not profess to get the quantity of putrescible nitrogenous matter by this process?—No.

11,383. What is the name of the process that you follow to get that?—We have not used any method; in fact, I believe there is no method of determining the quantity of organic matter of a putrescible kind present in water.

11,384. But what method did you follow for the albumenoid ammonia?—What is known as Wanklyn's process.

11,385. What you get is certainly less than what is in the water?—Certainly.

11,386. Will you just explain how that is—to what extent is that so?—When you distil nitrogenous matter with alkaline permanganate, you get a certain quantity of ammonia, as is universally agreed, by the destruction of this matter, the nitrogen is partly converted into ammonia, but we do not get the whole of the nitrogen in the form of ammonia, and there is no formula by which we know exactly how to multiply one to get the other; that is to say, we do not know what to multiply the albumenoid ammonia by in order to get at the quantity of organic matter.

11,387. Is it a matter of hypothesis as to the quantity of ammonia that you would get from any given quantity of nitrogenous matter?—Yes, there is no certain guide; I think that is universally known.

11,388. What have you taken?—We have made a kind of illustration which may, perhaps, illustrate the argument, and which I put in for what it is worth, and not with any attempt at definition. The quantities that we got were considerable, and if they were derived from a substance of the nature of albumen, it being supposed that these matters were obtained at first from albumenoid bodies, and if Mr. Wanklyn's original estimate were correct that you get two-thirds of the albumen in the form of ammonia—then I say (but it is a mere supposition obviously) that would give you ·7 parts by weight of nitrogenous organic matter, estimated as equal to albumen, per 100,000 of water. Now I say the experiments of most chemists would lead them to believe, as we believe, that the actual quantity of matter would be greater, and not less than that. I admit that it is a question of opinion, and I put the thing as an illustration, leaving it to the Commission to judge of its value; I found nothing upon it as fact.

11,389. Upon that assumption, what would be the weight in 100,000 parts of the average quantity of nitrogenous matter?—That would give about ·7 parts in 100,000, and I think it would have been greater, because I do not think you get so large a proportion of nitrogen as two-thirds in the form of albumenoid ammonia.

11,390. Is that all you have to tell us about the albumenoid ammonia?—Yes.

11,391. Now we pass to the nitrogen present as nitrates and nitrites; have you determined that in a number of cases?—In a few cases, not very many.

11,392. Does that appear upon tables you propose to hand in?—No; the determinations we have made ——.

11,393. Will you just tell us shortly what they amount to?—I can give you a series which appear to us to have a great value. In Sea Reach at high water ·1502 parts in 100,000 is nitrogen, as nitrates and nitrites both together, and at low water ·0760. Then, on another day, at Erith we got ·1190.

11,394. At what time of the tide?—At high water. Then there was one other experiment made, samples being taken at high water, at two hours ebb and at five hours ebb upon the same spot.

11,395. And I think you have a second series at Erith, have you not?—Yes; this which I am now giving is the first of these series. I have three determinations, which were made upon the same day upon the same spot at high water, two hours ebb and five hours ebb, and I am anxious to state these quantities, although I am quite aware that such a small number of analysis cannot have more than a certain value. The quantities were, at high water ·0975; at two hours ebb ·0580; at five hours ebb ·0270, showing a reduction in the quantity of the nitrates, which, as the Commission well know, is a matter of some importance. At Charing Cross, in the sample we collected, the nitrates were determined, and the quantity was ·2436 at low water, which is very much greater. Now, there is one remark that I should like to make with regard to these three experiments last quoted, that they seem to me to illustrate the reduction of nitrates by organic matter, which has been very fully and ably treated by Dr. Angus Smith in his last report on the Rivers Pollution Commission. Dr. Angus Smith has recently published a work upon the reduction of nitrates by excessive sewage matter, showing that the nitrogen is given off ultimately as nitrogen gas; that is in the report of the Local Government Board.

11,396. With regard to this reduction of the nitrates and nitrites, what conclusion do you draw; is that a reduction which might be due to the effect of sewage?—I think so.

11,397. Then the sewage has the effect of reducing the nitrates?—An excess of sewage has that effect. I must explain that I should not have asserted that upon these few experiments alone, but the very elaborate experiments of Dr. Angus Smith seem to be illustrated by these figures.

11,398. Now, we come to the oxidised nitrogen; what quantity did you find at Sea Reach at high-water?—We found ·1502 at high-water.

11,399. What is the next matter of importance that you come to?—The next matter is the dissolved oxygen; we made some experiments upon that.

11,400. This requires a little detail. First of all, what method did you adopt?—The Schützenberger process.

11,401. (*Prof. Williamson.*) How did you collect the water in which the dissolved oxygen was to be determined?—We found from some experiments which we made that the water absorbed oxygen very rapidly indeed, so rapidly that if we stoppered a bottle in the boat and took it to the club house and then tested it, we got more oxygen than if we made the same analysis in the boat.

11,402. (*Sir John Coode.*) Have you actually made an analysis in the boat?—Exactly; they were all made in the dingey; we rowed out in a dingey, and took a three-litre bottle, and immersed it a foot deep in the water, filled it at that depth, and took as much pains as possible by moving the bottle about to change the water several times, so as, as far as possible, to get the water of a fair sample, free from the air.

11,403. You mean you endeavoured to drive out from the bottle the water which first went in?—Yes.

11,404. So as to change the water?—Yes; we placed the bottle under the water, and moved it round and round, and we did all we possibly could to change the water underneath the surface. Then we raised the bottle up to the surface of the water, and one of us was ready with the burette with a cork at the top with the solution, and another poured a thick layer of paraffin oil upon the top, and then we syphoned it down to one litre, so as to get the minimum of exposure.

11,405. Are you quite sure that you did not get an undue proportion of the matter in suspension by that test?—I do not think it affected the oxygen test, which was the purpose of the experiment; we thought we should get in this way a fairer measure of the dissolved oxygen by doing it upon the spot than by taking it to the club house; if we carried it to the club house however carefully, even covered with petroleum, it gave a larger amount of oxygen; it absorbed oxygen during the journey.

11,406. (*Mr. Lumley Smith.*) Would you finish describing your process?—After that we applied the usual Schützenberger method, which is well known.

11,407. Do you consider it of importance to describe this method, or not?—No, I do not. I think the chemists among the Commissioners pretty well understand the details, I was then going to illustrate the method as to the absorption of oxygen. I can in some private notes, put in the experiments, if the Commission think it worth while. Upon a certain day we took some water, and determined it in the boat by the method I have described, and found ·1 cubic inch per gallon. We then repeated our collection precisely in the same way, but we carried the bottle to the club house, which was near, and did the analysis half an hour after the collection, and we got ·14, though there was a stoppered bottle and a thick layer of paraffin at the top. Then we let it stand four days, and repeated the experiment, and then we got ·38, which is nearly as high, I think, as in the quantities found by Dr. Tidy; and that, although the bottle was stoppered and covered with petroleum. There must have been a diffusion of oxygen, I presume.

11,408. (*Mr. Michael.*) Do you mean in the same sample?—In a sample taken at the same time and treated in the same way.

11,409. (*Sir John Coode.*) Did that happen more than once?—Yes, in every case. We always found that if we kept the samples a short time the quantity of oxygen rose, and we always found that we got the lowest indications by taking them in the boat upon the spot.

11,410. (*Mr. Michael.*) The four days retention gave you ·38?—Yes, the greatest quantity of oxygen.

11,411. And the simultaneous one ·1 and ·14?—Yes; the latter was after it went into the club house.

11,412. (*Mr. Lumley Smith.*) At what time of the year were your experiments made?—It was in cold wet weather in October.

11,413. Was that a kind of weather that was favourable to the water?—Decidely, because the solubility of the oxygen is greater in rough weather, there is more agitation in the water, and I should say the probability of aeration is greater decidedly.

11,414. I think you have a few results which you propose to give us of the amount of oxygen found, how have you taken them?—I have them in parts by weight per 100,000 parts, and also in cubic inches per gallon.

11,415. (*Dr. Stevenson.*) We have had the proportion given in cubic inches, and I think we will keep to that plan?—I will give it in that way. The reason we used parts by weight was that we were anxious to compare the parts by weight with the weight of the matter to be oxidised.

11,416. (*Mr. Michael.*) Have you the comparative results at the same time?—I can give you parts by weight in one column, and in the next, cubic inches to the gallon, the nearest I could go would be to give the average.

*The table was handed in, and was as follows:—*

| — | Parts by Weight in 100,000. | Cubic inches in one gallon |
|---|---|---|
| Water saturated with oxygen from air at 15° C., and 760 mm. P. | 0·85 | 1·74 |
| Erith, Oct. 11, 1882, high water | 0·11 | 0·22 |
| „ „ 29, „ „ (unusually high tide, rough water). | 0·20 | 0·41 |
| „ „ 15, „ flood | 0·11 | 0·22 |
| „ „ „ „ „ (near causeway) | 0·06 | 0·12 |
| „ „ 21, „ „ (heavy rain) | 0·12 | 0·24 |
| „ „ 11, „ ebb | 0·11 | 0·22 |
| „ „ 25, „ „ | 0·05 | 0·10 |
| Average, excluding Oct. 29 | 0·09 | 0·18 |
| Charing Cross, Oct. 13, 1882, low water | 0·66 | 1·35 |

*Prof. C. W. Heaton, F.I.C., F.C.S.*

7 March 1883.

11,417. (*Mr. Lumley Smith.*) What result do you draw from that?—The quantity of oxygen was so very small as to be practically nil; as far as the oxygen in the water went, there was next to none. If you find that you get a tenth of a cubic inch in a gallon of water, that quantity is very little. What I say about the matter is that the impurities in the water keep the dissolved oxygen very low in spite of its rapid absorption from the air.

11,418. You find very little oxygen, and you attribute that to the impurity of the water?—Yes, because the experiment made at about the same time at Charing Cross, though not upon the same day, gave us a very fair quantity of oxygen. I saw yesterday from Dr. Tidy's result that our determination of oxygen at Charing Cross was almost the same as his, ours being 1·35 cubic inches.

11,419. I see that the sample you have there containing the lowest amount of oxygen is the one that gives ·05 of a part?—The ·05 is by weight, but that is almost an exact equivalent to ·1 of a cubic inch, it happens that the cubic inches to the gallon are almost exactly twice the parts by weight per 100,000; you get, for instance, ·11 by weight, and ·22 by volume.

11,420. Now you say that those samples were taken in October when the weather was cool?—Yes.

11,421. Have you any opinion as to what would be the amount of oxygen in the summer?—We have no experiments unfortunately. I wish we had, but it seems reasonable to suppose that the quantity we have in the summer will not be greater than the smallest quantity; my opinion is that we should find that that would be representative of the summer condition of the Thames at that place, at the various states of the tide there is no important difference.

11,422. Have you formed any opinion as to the amount of oxygen that is required for the respiration of fishes?—I have hardly formed an opinion upon that matter, but I would suggest that the quantity found by our experiments would be absolutely insufficient, it seems to me that this quantity of oxygen would make it impossible for fish to breathe.

Adjourned to Tuesday next, at half past 12 'clock.

# TWENTY-NINTH DAY.

## Tuesday, 13th March 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR P. BENSON MAXWELL.
SIR JOHN COODE, Mem. Inst. C.E.
PROFESSOR WILLIAMSON, F.R.S.

FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst. C.E.

WILLIAM POLE, Esq., F.R.S., *Secretary.*

(*Mr. Michael.*) The Erith local authority and ourselves have discussed as to the admission of certain documents. We have now the opportunity of going over those documents with the Erith local authority, and they are here signed by myself and Mr. Morice, and I propose that they should be put in.

(*Mr. Morice.*) I went through the documents with my learned friend Mr. Michael (*the same were handed in. See Appendix AJ*).

Professor CHARLES WM. HEATON called again.

13 March 1883.

11,423. (*Mr. Lumley Smith.*) I think you heard the evidence given by Dr. Tidy with regard to the amount of free oxygen?—Yes, I did.

11,424. Your figures are rather lower than Dr. Tidy's, are they not?—In Erith district our figures are rather lower; in other districts in the few experiments we made they agree very closely.

11,425. Could you give any reason which would explain the apparent difference?—The determinations that we made were made in a boat upon the spot, and in that way we avoided the small absorption of oxygen from the atmosphere which is apt to take place in the journey from the boat to another place.

11,426. In the journey from the boat the samples would acquire fresh oxygen from the air?—Yes; the difference is not a very considerable one, but I believe that would account for the little difference that there is.

11,427. Now with regard to the conclusion to be drawn from the amount of the albumenoid ammonia as to the quantity of oxygen in the water; you wish, I believe, to make an observation with regard to that for the purpose of illustrating your table?—The members of the Commission will remember that I said the results of our experiments had been to show that the quantity of albumenoid ammonia, that is, ammonia which is believed to be derived from putrescible animal matters, was considerable throughout the area examined, and that it did not appear to differ very much with the states of the tide. We found in flood tide quantities that were frequently as great as in the ebb tide when the sewage was coming down. The inference that we found upon that is that the quantity of oxygen in the water being kept constantly very low by the sewage, there is not time in the course of a single tide for the destruction of these nitrogenous matters, and also that these matters appear to undergo putrefaction before oxidation; they are, as a rule, putrefied first and oxidised afterwards.

11,428. (*Sir John Coode.*) I thought you said upon the last occasion that the oxidation was immediate?—Not with regard to these particular kinds of matters; such a substance as pure albumen, for instance.

11,429. You were speaking of the general body of sewage, and stated that it would absorb the oxygen?—Yes. Our experiments were only directed to get some evidence with regard to those bodies capable of putrefaction, not so much as to the bodies already putrefied. We wished to account for a smell which was found upon the river, and that smell appeared to us to come from putrefaction; so we used this method, thinking that that would give us the best evidence in regard to it. I should like to draw the attention of the Commissioners to Dr. Angus Smith's Report to which I have previously alluded. There are two or three passages in that report which seemed to confirm our conclusions in a very remarkable way. The report I am referring to is the report of Dr. Angus

Smith, the Chief Commissioner under the Rivers Pollution Act, pages 45 and 46 (*handing in the same*). Dr. Angus Smith made experiments upon the artificial aeration of sewage, that is to say, aerating it by forcing air through it to observe the effect of aeration, and he records those results, and they, are very interesting indeed. He makes this remark to begin with: "I must, however, add that in the following experi- "ments the amount of air supplied is greater than "that usually given to sewage water in nature." Then on the following page, page 46, he remarks: "The albumenoid ammonia is not much changed in "any of the aerated specimens." That is exactly what we found working in a different way upon the Thames, and then he says, "and this we might expect "from the absence of putrefaction." I only saw this a few days ago; he attributes the slow disappearance of the albumenoid ammonia in his experiments to the absence of putrefaction; the numbers are 10·6, 10·4, and 10·2.

11,430. (*Mr. Lumley Smith.*) Practically, with regard to your conclusion, as I understand, in warm weather putrefaction takes place tolerably fast?—Yes.

11,431. And during that time the sewage changes its character, does it not?—It does; it smells.

11,432. You have it accompanied by a great smell, and there is a disintegration and destruction of the sewage?—Yes.

11,433. But in cold weather is there putrefaction going on as fast as in hot weather, or does it go on at all?—It goes on much more slowly, so that there is a better chance for the oxygen to destroy it. When the putrefaction of a large quantity of matter is going on and the oxygen is being rapidly absorbed there is a smell, but when the putrefaction is very slow there would be no smell. You will have fæcal matter in the water unoxidized, but not smelling very much; it is only when putrefaction with insufficient oxidation takes place, in our opinion, that you have a smell.

11,434. (*Sir John Coode.*) Are the injurious effects of sewage, in your opinion, in proportion to the noxious smell?—That is more than I can say with safety.

11,435. There is no rule laid down upon that point?—Not amongst chemists certainly. I do not know whether physicians can answer the question in any way.

11,436. (*Chairman.*) With regard to the question whether sewage is injurious or not, can you answer any questions upon that point?—I cannot give any evidence upon that point.

(*Chairman.*) I mention it because I have heard, though I do not know what truth there is in it, that the men who go down the sewers are the healthiest men in London.

11,437. (*Mr. Lumley Smith.*) I asked you a question about the hot weather, but I did not ask you the corresponding question about the cold weather. In the cold weather does the sewage remain for some time in the water without changing its character?—It does.

11,438. Does that appear from your experiments with the albumeniod ammonia?—Yes.

11,439. In hot weather it changes character very rapidly, and is accompanied by a great smell; in cold weather it does not change its character so rapidly, but remains a longer time in the water?—Yes, and probably over a larger area.

11,440. You have some figures which you wish to give the Commission with regard to the quantity of oxygen in the water; will you mention them?—I gave a sort of suppositious case, that the albumenoid ammonia was derived from something analogous to albumen itself in order to get a number to work upon, and in that case I said the lowest quantity indicated by our figures would be ·7 of a part of nitrogenous organic matter in 100,000. On that assumption I calculated the weight of oxygen that would be required to destroy it; supposing the nitrogen were given off as gas and that the carbon were converted into carbonic acid gas, it would require 1¼ parts by weight of oxygen in 100,000 parts to destroy the albumenoids only; taking no account of other matter in the water which also requires oxygen. This I give as no more than an illustration of the very great quantity of oxygen that is required to destroy this organic matter, and when you compare that with the very small quantity of oxygen which we actually find, the matter seems to have a certain weight and value to me.

11,441. (*Dr. de Chaumont.*) Do you agree that the power of oxygen diminishes with the dilution, that is to say, with the smallness of the quantity of it?—I have no evidence to give to the Commission upon that point.

11,442. For instance, if the oxygen stands at 2 per 100,000 parts, its power is very much more in proportion than if it stood at 1½?—I know nothing upon that matter.

11,443. (*Dr. Stevenson.*) You gave some evidence to show that the amount of oxygen in the water at Erith was very low?—Yes.

11,444. And that it was very rapidly absorbed from the air?—Yes.

11,445. Would that tend to show that the oxidation was going on rapidly or slowly in the water?—It would show that the absorption of the oxygen by the water was rapid. I should consider that water nearly destitute of oxygen would absorb it more rapidly than if it were well aerated.

11,446. What inference would you draw from the rapid disappearance of the oxygen?—I should have thought the fact of itself no very convincing proof, but that the nitrogenous matter remained unchanged. I am not aware whether we have any experiments to show the rate at which oxygen is absorbed from the air, but whether it be slow or rapid, the nitrogenous matters do not get readily oxidized; that is all we can get.

11,447. (*Sir John Coode.*) If the absorption of oxygen is so extremely rapid in a bottle, would it not be equally rapid in the river?—There is no doubt it would.

11,448. The absorption of oxygen would not go on more rapidly in bottles than in the river?—No; undoubtedly the absorption of oxygen in the river must be very rapid.

11,449. If the quantity keeps very low and the absorption is so rapid as you say, what becomes of the oxygen which is absorbed?—That is absorbed by the sewage bodies. We find so much putrescible matter in a flood tide, that it is plain the oxygen does not destroy the whole or even any very large portion of it in the Thames.

11,450. Does it not come to this, that the oxygen in the water is not enough to oxidize the sewage?—Certain matters in the sewage are not eaten up; these nitrogenous matters, one would say, were tougher, and resisted the action of the oxygen.

11,451. (*Dr. de Chaumont.*) Is it not the fact that the nitrogenous matter putrifies more rapidly than non-nitrogenous matter?—Yes, but it does not oxidize to any extent until it is putrified. I think the cold arrests putrefaction, and so indirectly the oxidation, and also that there is a very large quantity of oxygen required; however rapid the absorption of oxygen from the air may be there is plenty for it to do.

11,452. (*Mr. Lumley Smith.*) Do you consider that you find oxygen enough at present in the water to oxidise the nitrogenous matter which is found there?—It would be a question of space I think.

11,453. Taking it where you have sampled the water and have ascertained the amount of oxygen, and have either ascertained or estimated the nitrogenous matter, do you find oxygen enough to oxidize what is there?—No; from Woolwich down to Greenhithe we find the water polluted at all times of the tide with nitrogenous organic matter, and we find very little oxygen.

11,454. Do you consider that there is oxygen enough there for the respiration of fishes?—That is more a physiological question than a chemical one; but I should like to draw the attention of the scientific members of this Commission to the very

*Prof. C. W. Heaton.*

13 March 1883.

small quantity of oxygen that we find present, and I will leave it to them to decide whether it is sufficient. I say as a chemist, however, that I should think the quantity of oxygen which I found in this district was insufficient for the breathing of fishes; but as it is a physiological point, I should prefer not to give a further opinion than that upon the question.

11,455. (*Dr. Stevenson.*) You have paid attention to the subject of physiological chemistry, I presume; you lecture at some schools, I believe?—I have done so, but not completely. I could not say what quantity of oxygen a fish would require for its respiration.

11,456. (*Mr. Lumley Smith.*) I believe you have taken some samples of mud, have you not, at Erith?—Yes.

11,457. And you kept them in your laboratory for some time?—Yes.

11,458. Could you tell us what happened to them; did they change their character?—Our examinations of the mud were unfortunately commenced very late in the year. We did not make very many observations, and I cannot say that I think they are very conclusive.

*The Chairman* intimated that the evidence of the witness appeared to be largely of a hypothetical character, whereas the question before the Commission was one of fact.

(*Witness.*) I can only of course venture to suggest an explanation of the facts observed.

11,459. (*Mr. Lumley Smith.*) Did you take some of this Erith mud into your laboratory?—Yes.

11,460. What happened to it when you kept it in the laboratory?—In a few days it smelt most offensively, and was full of large red worms.

11,461. Which you had not seen before?—Which I had not noticed before.

11,462. Not in the specimen which you took?—They were certainly not there when we took the specimen; they were observed in a few days.

11,463. (*Chairman.*) They must have been hatched, I presume?—There they were.

11,464. (*Dr. Stevenson.*) Do you think that those worms are characteristic of sewage?—I do not know that at all.

11,465. I suppose in a pond on Hampstead Heath at the top of a hill there is not much sewage?—I presume not.

11,466. Do you know that mud worms exist there?—I give no opinion upon that. I know only that the mud smelt badly, and that there were worms in it.

Cross-examined by Mr. Michael.

11,467. We have heard from some witnesses that the presence of sewage was determined because there were no worms in the mud. Do you mean to say that this mud contained sewage because there were worms in it?—No.

11,468. If I followed you rightly, you found a very small quantity of oxygen in the water?—In the water at Erith.

11,469. Will you state the mode in which you proceeded in making your determination?—I collected the water in a bottle, and in drawing it out of the river we covered it with a layer of paraffin oil as it came out, so that the bottle should be completely full; then we syphoned it off carefully down to one litre, and then immediately added from an alkalimeter which was standing ready in the boat the Schützenberger solution, and then having got the number of measures required to destroy the blue colour of the re-agent we drew off another litre from the same bottle, aerated it by violent and repeated shaking, and then repeated the determination, the whole thing being done in a very short time.

11,470. After keeping this water three or four days with a cover of paraffin oil, did I rightly apprehend you to say that there was three times the quantity of oxygen that there was previously to be found in the water?—Yes, just about that.

11,471. Where do you tell the Commission that the oxygen comes from?—I have no doubt it came from the air.

11,472. In spite of being covered with the paraffin oil?—Yes.

11,473. Now I will ask you this: if it is so impossible to prevent oxygen from getting to the water in a bottle under those circumstances, must not the water in the river itself, exposed as it is to the air, much more rapidly absorb oxygen?—Yes, undoubtedly.

11,474. Is it not the fact that the sewage is being constantly subjected to fresh accesses of oxygen brought into it from the air, the effect of which is to decompose it?—Undoubtedly.

11,475. Therefore, your finding at that particular moment only a certain quantity of oxygen, and in four days three times the quantity, shows, first, that a certain amount has been taken away to decompose the sewage, and, secondly, that fresh accesses of oxygen are continually coming into the water?—Certainly. Upon the last occasion I gave evidence as to the reduction of the nitrates in the water by sewage; now the fact that the nitrates are reduced is in itself, I hold, a strong evidence of the insufficiency of the oxygen; the sewage draws upon the nitrates, not only upon the dissolved oxygen of the water.

11,476. Now a word more with respect to Dr. Angus Smith and his report. I will not trouble the Commission by reading it. Is it not the fact that he makes these two propositions: first, that sewage running in water under ordinary circumstances, and not in sewers, is not deleterious to the public health?—I cannot answer that question.

11,477. But you quoted Dr. Angus Smith's Report. Is not that one of the conclusions at which he arrives?—Possibly; but honestly I have not read it. I found this report only a few days ago, and the passages I have quoted struck me as a valuable illustration of the evidence I had to bring forward.

11,478. I will quote one passage from the report.

*Mr. Lumley Smith* objected to the question.

*The Chairman* stated that the question might be put.

11,479. (*Mr. Michael.*) I will refer you to page 34 of the report, where Dr. Angus Smith is justifying his former report; he says, "This raises a question to be solved, but the fact is certain that fevers have not been traced to the escape of gases of putrefaction when there has been a large amount of water and exposure to the air. But they have been found when the water is not very great in amount, and the decomposition is made under cover as in sewers." Is not that from your experience the real distinction between sewage in sewers and sewage exposed to the air in running water?—I cannot say yes or no to that question. The fact is, I should not like to answer the question without studying the passage, and carefully considering it. I am not a medical man. I know nothing of its influence upon health.

11,479*a*. You know nothing of the application of this matter to health, or of physiological chemistry?—No, not as enabling me to answer your question.

11,480. Now a word or two further with respect to your analyses. Am I right in saying that nearly all of them were conducted upon water containing suspended matter?—Undoubtedly.

11,481. In some cases, if I rightly apprehended you, you took the water when the bottom was stirred up, as in the wake of a steamer?—That happened in one case; but if you turn to the table, I think you will find that that is excluded. We thought that in two samples the albumenoid ammonia was very high indeed, and we struck them both out because we thought the conditions of the river at the moment were unfair.

11,482. Am I right in saying that the river varies

in suspended matter in proportion to the depth, and that unless you had a very large number of analyses you could not draw a fair average?—I should be very sorry to make anything much of that average. I have been most careful not to overstate our case to the Commission. In that particular we found large quantities, but very variable quantities.

11,483. What is the result which you would wish the Commission to understand as to the difference between free ammonia and albumenoid ammonia? Where you find a small quantity of saline ammonia and a large quantity of albumenoid ammonia, what is the conclusion you would draw?—I should draw no conclusion from it in the conditions of our experiment with suspended matter in water.

11,484. Therefore, you have no means of guiding the Commission as to anything that is to be drawn from the great mass of your experiments?—I think, as regards the free ammonia, very little will be deduced from them, except that there is general sewage pollution; but that, I presume, will not be doubted.

11,485. Then the quantity of saline ammonia, if I rightly understand what you say, would furnish no indication as to pollution?—I would not say that; I would only say that for the purpose of the argument that I wish to bring out, the free ammonia does not bring out results which are useful to me.

11,486. Now you have made two analyses of filtered water?—Yes, I have.

11,487. Is it not the fact that with regard to those analyses the quantity of matter found was very nearly the same at Kingston as at the Corinthian Yacht Club at Erith, the point you have taken as showing pollution?—If you are referring to samples 41 and 42 there is not much difference.

11,488. Therefore, as far as we are to be governed by those two analyses, the point you have selected, namely, at the Corinthian Yacht Club, shows the same amount of impurity by the albumenoid ammonia test as you find at Kingston?—But you must not overlook the fact that those were filtered samples, whilst the Kingston water was unfiltered.

11,489. But the Kingston water is in a state fit to be drunk, is it not?—I do not know that.

11,490. Was there any suspended matter in the filtered water?—That I cannot say; but that sample was struck out of our table, and was struck out because we had nobody here to give evidence as to who took it or how it was taken.

11,491. Had you any means of determining the quantity of suspended matter at varying depths in the river?—No.

11,492. Would your analyses make any discrimination between the organic matter alive and dead?—No.

11,493. If there were a great number of microscopic animals or microscopic vegetables, algæ or confervoids, you would have had the same means by analysis as you would by chemistry of ascertaining the amount of albumenoid ammonia?—I think not.

11,494. Will you explain why not?—Because we know, as a matter of fact, that certain sewage matters which are thrown into the river—the common sewage of the river—does yield a large quantity of albumenoid ammonia. I quite admit the weaknesses of the method in many particulars. All these things are well known to every chemist; but it is generally agreed amongst chemists, I think, that the albumenoid ammonia in a sewage polluted river does come from the sewage.

11,495. With regard to dead animal and vegetable matter, is that composed of any gases different from the gases which make up sewage matter?—No.

11,496. Therefore, as far as chemistry is concerned, can you discriminate between organic, animal, and vegetable matter which is dead in the water, and animal and vegetable matter which has come out of the sewage?—I think we can in this way: the sea-water contains much animal nitrogenous matter living and dead; the sample we took at night was when the water was covered with phosphorescence. Now that water, although it contains much nitrogen, does not yield albumenoid ammonia. I think the albumenoid ammonia is perhaps the best test we have in a water of this kind for sewage matter.

11,497. (*Sir P. Benson Maxwell.*) Laying aside the fact which seems to you to import that this is a water polluted with sewage, if you were given a sample of water, and were not told where it was drawn from, and you found there was albumenoid ammonia in it, would the inference be irresistible that it must come from the sewage; might it not also come from these confervoid and other organic substances, such as were suggested by Mr. Michael?—If I knew nothing of the history of the water I should draw a much more guarded inference than I should from the Thames, where I know that sewage is thrown in.

11,498. When you find albumenoid ammonia in the Thames, you say, "I know that comes from some "organic substance, and as I know the sewage is "thrown into the river I infer that it comes from the "sewage"?—Yes.

11,499. Supposing that you were supplied with a sample taken from a river in America, and you found this albumenoid ammonia in it, you would not necessarily come to the conclusion that the river was polluted with sewage, would you?—I could not go further than saying that it was polluted by nitrogenous organic matter.

11,500. (*Mr. Michael.*) All you say is, "I find a "certain quantity of nitrogenous organic matter "which I assume comes from sewage"?—I think you rather understate my case.

11,501. (*Chairman.*) It seems to me that you answered the point when you answered Sir Benson Maxwell's question. You say that all you know is that it proceeds from some nitrogenous matter, but whether it was sewage, or fæcal, or some other organic matter, you could not tell?—Yes. I leave the inference to be founded upon that, that the sewage is the cause of the very large quantity of albumenoid ammonia that we find there.

11,502. (*Dr. de Chaumont.*) Is it not the fact that no chemist founds his observations upon the presence of one particular ingredient; you would take into account the free ammonia and the amount of chlorine, and also you would desire to have the history of the water before you could arrive at the source of pollution?—Yes, quite so.

11,503. (*Mr. Michael.*) Therefore, chemical analysis does not enable you to say that there is so much pollution in the river?—No.

11,504. As far as your analyses have gone, may they not be taken to be merely analyses of the suspended matter in the water?—Not only that, but analyses of the matter both dissolved and suspended in the water when the sample was taken.

11,505. By the combustion process does not the same impossibility apply in discriminating between sewage matter and animal matter?—I think there is no impossibility in the matter we are dealing with; it seems to me certain that the albumenoid ammonia found in our experiments comes from nitrogenous organic matter capable of putrefaction.

11,506. So would the million animalculæ in 10 drops of water?—No, pardon me, they do not give so much life as the sea-water.

11,507. Assume sewage poured out into oxygenated water fed upon by animalculæ, and 10 drops of that water containing a million of those animals dead abstracted from the water, and you as a chemist analysing those 10 drops of water, could you tell whether the carbon or the nitrogen, or the results obtained by the albumenoid ammonia test, were really due to sewage, or to the decaying bodies of those animals?—I could not say with certainty.

(*Sir John Coode.*) I think I understand the witness to say that he does not put it so high as absolute proof, but that it is a very strong inference.

(*Witness.*) Yes, that is what I mean.

11,508–9. (*Chairman.*) As I understand, a sufficient number of dead dogs would produce that effect?—Yes.

*Prof. C. W. Heaton.*

13 March 1883.

11,510. But there not being that sufficient number of dead dogs there, but you knowing sewage to be there have attributed that to the sewage?—Yes, that is so.

11,511. (*Mr. Michael.*) Now, passing from that, I think you have resided, have you not, at Erith for some time?—Yes.

11,512. What do you say with respect to the noxious trades which are conducted on both sides of the river there?—Those noxious trades are very disagreeable.

11,513. Have you had to complain constantly on the vapours which issue from those manufactories of both sides of the river?—Undoubtedly. I am very familiar with them all. I gave evidence before the Royal Commission with regard to them.

11,514. Do they exist at the present time?—They do.

The witness withdrew.

Professor Richard V. Tuson, F.I.C., Professor of Chemistry in the Royal Veterinary College; Associate of the Society of Medical Officers of Health, examined.

*Prof. R. V. Tuson, F.I.C.*

11,515. (*Mr. Balfour Browne.*) You made all the experiments which have been spoken to by Professor Heaton?—Quite so.

11,516. You were with him, were you not?—Yes.

11,517. And as far as scientific matters are concerned you have nothing to add to his evidence?—I have nothing to add.

11,518. (*Chairman.*) Do you concur in what has been said by him in answer to questions put by Mr. Michael in cross-examination?—Quite so.

11,519. (*Mr. Balfour Browne.*) Have you been acquainted with the river for a much longer period than Professor Heaton has?—I believe so, for the last 22 or 23 years.

11,520. How is that; have you been a yachtsman?—I have been yachting all the time constantly upon the river.

11,521. I think for a considerable number of years you have been resident at Erith?—I have been resident at Erith for 11 years.

11,522. And have you been during those 11 years frequently upon the river?—Yes, at all times of the day, and frequently at night.

11,523. And you have constantly been at the yacht club which is upon the side of the river?—Yes.

11,524. Are you able, apart from chemical analyses, to judge of the river from the condition of the river itself?—I consider myself fully qualified from personal knowledge to judge of the general condition and appearance of the river.

11,525. Is it getting better or worse, speaking from what you know of the condition of the river?—I should say it is steadily getting worse and worse from year to year.

11,526. (*Chairman.*) Would you give the Commission the boundaries between which it is getting worse?—I would take it, say, from Woolwich Piér as far as Greenhithe.

11,527. (*Mr. Balfour Browne.*) Is it true that for the last 10 years the river has been getting worse?—Undoubtedly, judging from the appearance of the river, the blackness of the river, and the stench arising from it, and its turbidity.

11,528. In all those respects you say it is getting worse?—Yes.

11,529. And within the limits which you have mentioned to my Lord Bramwell?—Yes.

11,530. Do you know the middle of Long Reach?—Yes.

11,531. Is the river in that condition so far down as Long Reach?—Yes.

11,532. Is it turbid, black, and sewage like?—Yes, turbid, black, and sewage like, with innumerable bubbles slowly or sluggishly rising and discharging gas, and in hot weather this is accompanied by a most fearful stench.

11,533. (*Sir John Coode.*) Do you see that gas rising at this period of the year?—No; for the reason that I am not so frequently upon the river at this period of the year.

11,534. (*Mr. Balfour Browne.*) Can you tell the Commission whether the bottoms of boats and yachts have to be scraped more frequently than was formerly required there?—Yes.

11,535. (*Sir P. Benson Maxwell.*) I suppose you mean that a quantity of stuff collects upon the bottoms of the boats?—Yes.

11,536. What kind of stuff is it?—A blackish kind of mud, followed very often by a vegetable growth; and when it is scraped off the stench from it is very bad.

11,537. What kind of smell is it?—It is like the smell of fæcal matter decomposing.

11,538. (*Mr. Balfour Browne.*) Have you any knowledge of bathing at Erith?—When I first went to live there, 11 years ago next June, bathing from the dummy at the end of the pier used to take place nearly every day, whereas I never now see any bathing taking place there except by mud-larks, such as you would see bathing off a place like this; but the gentlemen of the place never bathe there now.

11,539. You know the Corinthian Club; do you know whether the stench there is much worse than it used to be?—Yes, at low water in hot weather the stench is exceedingly bad.

11,540. Does this evidence which you have been giving to the Commission bear out the results of the scientific examinations which you made with Professor Heaton?—Yes, I think so.

Cross-examined by Mr. Michael.

11,541. Did I understand you to wish the Commission to regard what you said with reference to gas as being an inevitable test of sewage in water; if sewage is poured into a running stream is there a large quantity of gas given off in it?—Yes, I look upon that abundant and general evolution of gas accompanied by a bad smell and accompanied by black turbidity in the water as evidence of sewage, because I have seen immense volumes of sewage matter vomited forth from the northern outfall having exactly the same appearance.

11,542. But is the presence of gas in water to be taken as indisputable evidence of the existence of sewage in the water?—I should say that fœtid gas was.

11,543. Did you ever analyse what the mud was?—Never; I simply smelt it.

11,544. Now, with regard to the mud at Erith, has that in your opinion increased or decreased in quantity?—My opinion of it is that it has increased especially by the causeway.

11,545. Are you aware where the outfalls of the sewage at Erith are?—I know one small pipe coming down just below Erith Pier.

11,546. Is that the place where the bathing used to take place?—No, it is above it, and at high water.

11,547. What do you say with respect to the noxious smells which are given off by the manufactories upon the banks of the river?—I say that as the result of many years experience I am able to distinguish five distinct bad smells, four of them arising from chemical works upon the banks of the river, and one of them from the river itself.

11,548. Are they particularly disagreeable and noxious in your opinion?—As to their being noxious I can offer no opinion; but as to their being obnoxious or offensive, I am very strongly of opinion that they are.

*Prof. R. V. Tuson, F.I.C.*

13 March 1883.

11,549. (*Chairman.*) Do you mean that you can distinguish them all at the same time?—I will not go so far as that; but I am living, as the crow flies, about three-quarters of a mile from the river, and when the wind sets in a certain direction towards my house I can smell Calenders'. I can smell another place which is known there as Rose Cottage, where they make scutch and glue, and things of that sort. Then there is another work which I can distinguish.

11,550. (*Sir John Coode.*) Which predominates, you mean?—Yes.

11,551. (*Mr. Michael.*) Is not it the fact that at the Corinthian Club House there is an eddy of the river, that the river does not run as it does upon the other side, but that there is an eddy which comes right back?—Yes.

11,552. So that whatever is in the stream is brought back to this particular spot?—Yes.

11,553. (*Sir John Coode.*) You said that the river was getting steadily worse year by year. Would you say it was worse last year than in the summer previously?—No, I would not say that, because the weather was cold last year.

11,554. What you mean is, that there is a steady growth for the worse, setting aside exceptional seasons?—Yes.

11,555. (*Dr. Stevenson.*) With regard to the table that Professor Heaton put in, showing the parts of oxygen absorbed, does that mean absorbed by the permanganate test?—Yes.

*Mr. Balfour Browne* stated that he had no questions to ask the witness in re-examination.

Dr. Charles Meymott Tidy recalled and further examined.

*Dr. C. M. Tidy.*

11,556. (*Mr. Balfour Browne.*) I think you wish to explain a little further your experiments on the oxidation of sewage?—Yes. I beg to hand in a photograph of the apparatus used by me in my oxidation experiments. Dr. Frankland raised some question about this apparatus; this apparatus was a series of troughs put up in the garden of a house which I specially took, for the experiment, in the north of London. The series of experiments which were made upon the oxidation in running water occupied about five months with this apparatus, and in all 118 experiments were made with it. Dr. Frankland, in answer to these experiments, referred to the circumstances that I had said in my paper that, in the first instance, all my results showed absolutely against my views of oxidation. I should like to say that the conclusion of the sentence was that "the reasons were manifest." The reasons why my results did show against oxidation were these:—First, that "blacks" would keep getting into the water from the chimneys, which increased the organic carbon very largely; and, secondly, that at first the troughs were simply made of wood, to which various matters would be apt to adhere. In order to meet that objection I had to adopt a very large number of contrivances; the first was the lining of the trough with glass, which was cemented to the wood, and which was distinctly noticed as being cemented to the wood; that was in order to prevent the blacks and other matters being caught in the wood; the second was that the outside was covered with cotton-wool in a most elaborate method to allow the free access of air, but to prevent the increase of organic carbon from the blacks. After I had completed this work I never failed once in proving a decrease of organic carbon. The sewage was filtered and mixed with New River water, and every trough was washed out at the termination of every experiment; it was pumped. You will see the pump at one side; there was a little cistern at the top and a little cistern at the bottom in order that it should go through the trough again. Then I answered a question about bacteria on the last occasion. I have no record of any bacteria being noted, but I cannot say but what bacteria were formed, but if they were they would occur in the river just as they would in these troughs; and if they assisted oxidation they would assist it in the river just as they would in these troughs. I trust the Commission will excuse my mentioning these experiments of mine, but they cost a great deal of labour, and to my mind those experiments have never been answered. Then there was another thing referred to as one of my arguments in favour of oxidation, that I had spoken of having seen the River Irwell loaded with black matter; and Dr. Frankland, I think, quoted me as having said that when it passed through Warrington it was perfectly clear, whereupon, Dr. Frankland said that the River Irwell did not pass through Warrington. I did not say it did. What I said in my pamphlet was perfectly distinct upon that point, and I think it is necessary that I should just put it right. I did not call it the River Irwell, because I was perfectly aware that the Mersey joined it. I called it "the stream"; I did not call it the Irwell at all. What I stated was, "I have seen the River Irwell at "Manchester polluted with every form of filth, per-"sonal and manufacturing; at Warrington, after a "flow of 9 miles, the offensive character of the stream "had entirely disappeared." Then I give the figures to show that, as a matter of fact, the Irwell was a little better than the Mersey.

11,557. (*Sir John Coode.*) During the experiments the apparatus was entirely encased in the cotton wool?—Entirely; indeed I think the amount of care taken in carrying out these experiments can hardly be imagined.

The witness withdrew.

Mr. Lionel S. Beale, M.B., F.R.S., examined.

*Mr. L. S. Beale, M.B., F.R.S.*

11,558. (*Mr. Lumley Smith.*) My Lord, this evidence is to show how far any information can be got from the microscope. (*To the witness.*) I believe you are a Fellow of the Royal Society?—I am.

11,559. (*Chairman.*) And of the Royal Microscopical Society?—Yes.

11,560. (*Mr. Lumley Smith.*) Now, I believe you received, did you not, from Dr. Collingridge, various samples of mud from different banks between Gravesend and Chelsea?—I received 25 of them.

11,561. And you received them for the purpose, did you not, of investigating them with the miscroscope?—I did.

11,562. Have you examined them, and are you able to tell us to what extent they show signs of sewage?—Principally from the presence of matter which looks like fæcal matter, and from the presence of many substances which have passed through the alimentary canal.

11,563. Will you allow me to interrupt you, you have examined them for that purpose, have you not?—Yes for that purpose.

11,564. I think it would be convenient, before you state what you found, to ask you to say one word upon the method you adopted. If a portion of the mud is placed upon a glass slide immediately, are you able to examine it with facility?—You cannot do so, because the particles of sand are so large as to prevent you from getting a sufficiently thin layer to see the more important structures.

11,565. Then there is a practical difficulty in getting a sufficiently thin layer of mud if you place the mud immediately upon the slide?—Yes, there is a practical difficulty.

11,566. I believe you then tried, did you not, putting it into the water and stirring it up and letting it settle?—In this way you can get the light particles, but you can form under those circumstances no idea of the proportion which the organic materials bear to the sand.

*Mr. L. S. Beale, M.B., F.R.S.*

13 March 1883.

11,567. Then that did not answer?—That did not do.

11,568. Then will you tell the Commission what was the mode that you found satisfactory?—I took a small piece of the mud, perhaps the size of a pea, and mixed it with an equal quantity of glycerine, and then, when the mixture was complete, I examined small portions from different parts of the mass under thin glass, taking care to separate the coarser particles of sand, so as to get a sufficiently thin layer.

11,569. Is that mode, in your judgment, satisfactory?—Yes, fairly satisfactory.

11,570. Has it any advantage with regard to the length of time that the mud will keep without undergoing change?—By this process one is enabled to keep specimens of different muds for almost any length of time, examine them at leisure, and compare one with the other. No change takes place; they may be kept for months, and I believe for many years, 15 or 20 years, without change.

11,571. Were you able by those means to see almost all the constituents of the mud?—I think so. I paid more attention to the organic than to the inorganic constituents. I paid little attention to the particular kind of sand.

11,572. Now with regard to what you do find under the microscope; first of all, does the microscope give you any information or not as to the quantity of each constituent that there is in the mud?—I am afraid only roughly.

11,573. Of course when you look through your microscope you see something which may have come from sewage, but in what way can you get roughly at the absolute quantities?—By noticing the number of particles in one field, and then shifting the specimen onwards a certain distance, and noticing whether, say in 20 fields, you meet with one, two, or more specimens of the same substance or kind of thing.

11,574. If in 20 fields you only find one specimen of one thing while in 20 other fields you find 20 specimens of another, you assume that there are 20 times as much of the one thing as of the other?—Quite so.

11,575. Have you identified in the mud any substances which had formed part of human excrement?—Yes, human excrement itself. I also found portions of muscle, of vegetable fibre, and starch granules.

11,576. Did you find any other?—I found yellow elastic tissue and various forms of vegetable tissue. The first is very striking, it is very indigestible, and is not dissolved by the juices of the intestines of the stomach.

11,577. (*Dr. Stevenson.*) Would you tell the Commission what yellow elastic tissue indicates?—One form of yellow elastic tissue comes from the ligament of the neck, pieces of it are taken off in a mutton chop, another form comes from the larger arteries of the body. It is hardly possible to eat a mutton chop without taking portions of the yellow elastic tissue from the ligament of the neck, which keeps the head of the animal raised. Not only so, but you can distinguish, I think, with tolerable certainty, the difference between the yellow elastic tissue from the artery and that from the ligament of the neck.

11,578. (*Mr. Lumley Smith.*) First of all, I will ask you generally; these matters are constituents of human food, are they not?—Undoubtedly.

11,579. Now, notwithstanding their having passed through the alimentary canal and through the sewer and been in the Thames, do you in fact find those elements in the mud?—Yes.

11,580. Have they well-marked characters which make them recognisable?—They have a very well-marked character; there is no doubt about them at all in many cases.

11,581. Now a word or two about each; first of all, with regard to the vegetable tissue; what has that proceeded from?—Many different forms of vegetable tissue are found, but notably common cabbage.

11,582. Common cabbage might, of course, have fallen into the river, or it might have got there in the way which is suggested by you; is there anything to distinguish between whether it has come to an untimely fate and been drowned, or whether it has passed through the alimentary canal?—In many of the muds near Crossness one finds a vast number of these spiral fibres in exactly the same state as those which may be obtained from the fæces of a person who has had a meal of cabbage some time before.

11,583. The spirals are a portion of the vegetable tissue?—Yes, the spiral is the least soluble portion.

11,584. Is there anything in the colour which shows that the spirals have passed through the alimentary canal?—Not in the spirals, but in the tissue close to the spiral; this gets stained with the yellow matter which is so characteristic of fæces.

(*The witness handed in drawings illustrative of his evidence.*)

11,585. You say that you find these spirals in large numbers in the mud from near the Crossness outfalls?—Yes.

11,586. Do you find them in the other muds that you have examined?—In a good many. Of spiral fibres from vegetable tissue in the mud from Crossness, two specimens were found, taken from different places; in the mud from Barking bank; in the mud from Erith; three specimens in the mud from Beckton; in the mud from 40 feet below Barking outfall; in the mud from the bank at the upper end of the jetty at Crossness; off the centre at Barking outfall; at the sewer by the steps just above Woolwich Pier; in mud taken at East Greenwich; in mud taken at Blackwall, and in mud taken at Chelsea.

11,587. And you find vegetable tissues in a form and condition which, in your judgment, shows that they passed through the alimentary canal?—Yes.

11,588. Have you angthing more to say with regard to the vegetable tissue?—With regard to the spiral fibre, I ought to say that there are different forms of vegetable spiral fibre.

11,589. Do they resist the gastric juice?—Very much so, and they resist decomposition.

11,590. The rest of the fibre dissolves away from it and leaves the spiral, does not it, so that you get the spiral separate?—Yes, and you get portions of the spiral vessel and also some spiral vessels from tea-leaves and cells from tea-leaves.

11,591. Do you find those at all in the mud on the banks?—Yes.

11,592. Are you able to tell us, with regard to each of these matters, where you found them?—I am able to do so with regard to the spiral vessels generally, but I have not separated the spiral vessels of different plants.

11,593. Do you find the spirals at Erith?—Yes.

11,594. And at East Greenwich?—I think so.

11,595. Now with regard to the starch granules—what are they?—They are probably from bread principally, but in some of the mud I have identified wheat-starch and rice-starch, and several specimens of starch, as to which I could not determine the plants from which they came.

11,596. They all seemed to have been through the alimentary canal?—One could not say that with certainty, but probably.

11,597. Where do you find them—in what muds?—I have found them in Crossness, Barking outfall, and Gravesend. I think they might be found probably in many other muds, but I did not look very carefully for them.

11,598. Did you find the wheat-starch looking as if it were partly digested?—Yes, from bread. I noted several granules of starch together, just as one sees them in bread.

11,599. Now, with regard to muscular fibres; those, I presume, come from meat?—Yes, from cooked meat.

11,600. Those are portions which have resisted digestion?—Yes.

11,601. Do you find them more especially from any

particular kind of meat?—I think mostly from beef which has been well cooked, the fibres being rendered hard, and undergoing very little change, probably remaining for months in the same state and often exhibiting delicate transverse markings which are so characteristic that you can distinguish this tissue from anything else.

11,602. Are we to take it that well done beef is more indigestible than anything else?—I should hardly go so far as that.

11,603. (*Chairman.*) May we take that as a caution against eating the brown part of beef—the outside?—It is not so digestible.

11,604. (*Mr. Lumley Smith.*) Are you able to trace the change it has undergone from being in the river longer in some cases than in others?—Yes, some of the fibres are granular—broken up, while those obtained from the sewage itself, or from the banks near the outfall, have a yellow colour, and are very clear and distinct, many containing transverse markings, and several of them retaining the same appearance which they had when passed, and which depends upon partial digestion having taken place.

11,605. (*Sir John Coode.*) Would the length of time they had lain in the mud account for the characteristic markings having disappeared?—I am afraid I can hardly go so far as to say that, but some exhibit the markings and some do not; it is hard to say why, but in some of them, no markings could be seen at first, while by soaking these in glycerine for a time the markings came out.

11,606. (*Mr. Lumley Smith.*) I rather understood you to say that from the mud immediately near the outfalls you find this muscular fibre, in what I may call a more recent condition than you do further off; is that so?—I think it may be so.

11,607. Do you find the muscular tissue in other muds that you have examined?—In a great many; in two muds from Crossness, in three muds from Erith, one mud from Barking outfall, one from Gravesend—in one case very distinctly from sewage taken at the outfall just below Trinity Ballast office; also in a mud taken at East Greenwich, also in mud taken at Blackwall, and also in mud taken at Chelsea.

11,608. And you find this muscular fibre in various conditions of decay?—Yes; but it would be difficult to say, I think, whether that condition of decay depended upon the mere process of digestion, or whether it was due to being macerated for a long time upon the banks, owing to the slow action of the water.

11,609. However, there you found it?—Yes.

11,610. (*Chairman.*) Could you at all tell us this. Suppose you took a pint measure full of the stuff brought to you, could you say what proportion of the contents were fæcal matter?—No, but it would be a very small portion.

11,611. (*Mr. Michael.*) Have you made any quantitative determinations of these various matters?—No, it would be impossible.

11,612. (*Chairman.*) Would you say $\frac{1}{1000}$th part of bulk?—I should think more than that.

11,613. Could you tell us from what was brought to you, whether, as it was taken from the river, one part was lower than the other, that is to say, suppose you took a spade full and got up a quantity, could you tell from what was brought to you, that a part of what was brought to you was the lower part, and part the upper?—I do not think I could.

11,614. It was not brought to you in such a condition that you could tell?—No.

11,615. At all events you could not say how much more than $\frac{1}{1000}$ part was fæcal matter?—No.

11,616. But could you say of the other $\frac{999}{1000}$ parts that they were not fæcal?—I could; they were principally sand—the bulk of the fæcal matter would be very small.

11,617. I thought it possible that there might be a large part of the remainder that you could not attribute to any particular source.

11,618. (*Sir John Coode.*) But the sand would not surely be in the proportion of $\frac{999}{1000}$?—I have not examined it with that view, but I have been astonished at the small amount of organic matter in proportion to the amount of mineral matter.

11,619. (*Chairman.*) Was that because you expected to find more, or because the smell and appearance indicated more?—Because the smell and the appearance indicated a great deal.

11,620. (*Prof. Williamson.*) Where were your samples taken mostly, from what part of the river?—They were taken at several places between Gravesend and Chelsea; some upon the banks of the river and some at a distance from the bank.

11,621. (*Dr. Stevenson.*) You mentioned the smell and the look; have those muds much smell; what time of the year was this?—This was in November, December, and January. Some smelt; those from Crossness smelt very strongly, while others smelt hardly at all when I got them.

11,622. Did you observe any relation between the smell and the amount of organic matter?—Yes, I think so.

11,623. (*Mr. Lumley Smith.*) But do you get a great deal of smell with very little fæcal matter?—Certainly we do; there may be a small amount of organic matter, but the smell may be very bad.

11,624. (*Prof. Williamson.*) The Commission have been told that the banks of the river have been found in some places to be covered with slimy material, which appears to be of organic origin; have you had such material as that for the purpose of examination with the microscope?—I have not.

11,625. Round Erith it was stated that there was a great deal of slimy matter deposited upon the banks?—I have seen it myself.

11,626. But you did not examine it?—No; it was in the summer that I noticed it, but the samples I examined were taken in the winter.

*Sir John Coode* suggested that it was desirable the Commission should know the precise spots at which the samples were taken.

*Mr. Balfour Browne* stated that he would have that made out.

11,627. (*Mr. Lumley Smith.*) (*To the witness.*) Before we pass from this question of the degree with regard to the mud being offensive in smell, in your judgment, as I understand, it is not necessary for that purpose that the fæcal matter should be there in a large proportion compared to the sand and other matter?—No, a very small proportion may have a very strong smell indeed.

11,628. So with regard to its noxious character, the same observation would apply?—Certainly; the foot of a fly might carry poisonous matter enough to poison a number of people or animals.

11,629. Would the relative proportion vary at different times of the year; I think you told us that it would?—I think so.

11,630. Would it depend at all upon the rate at which putrefaction is going on?—That is to say, the offensive matter evolved during the decomposition of the organic matter in the sewage, certainly.

11,631. I think we have got you now as far as the yellow elastic tissue; is that a substance which resists decomposition very strongly?—Yes, very strongly.

11,632. For how long do you find it resisting decomposition; is it a matter of hours or days, or what?—It is a matter of months.

11,633. Then it will stand for months before it decomposes?—Yes.

11,634. (*Prof. Williamson.*) Even when immersed in such a mixture?—Even when immersed in water.

11,635. (*Mr. Lumley Smith.*) I think you told us that you could identify the fibres from the neck of a sheep, and so on?—Yes, different kinds of yellow elastic tissue, all animal.

11,636. Where do you find those?—At Crossness, Barking Bank, Erith, off the end of the Causeway, from mud in a line with the centre of of the "Cornwall," 50 feet or 60 feet from the edge of the bank: Barking Outfall, Crossness, at the upper outfall, in

*Mr. L. S. Beale, M.B., F.R.S.*

13 March 1883.

sewage taken from an outfall below Trinity Ballast Wharf, and in mud taken at East Greenwich.

11,637. (*Sir John Coode.*) Where is the ballast wharf; what relation does it bear to the sewage outfalls; is it above or below? *The spot was pointed out.*

11,638. (*Mr. Lumley Smith.*) What is the next thing you come to?—Yellow fæcal masses.

11,639. What are they?—They consist partly of fæcal matter with the remains of food not digested, often with particles of sand, which become mixed with them as they are moved up and down by the tide, I think.

11,640. Are they masses which would attract the floating mud of the river, and would be likely to combine with the floating mud in suspension in the river?—I think so; being viscid, sticky stuff, it would.

11,641. The natural suspended matter of the river sticks to those particles and they adhere?—Yes.

11,642. What becomes of them then?—I think the organic constituents gradually undergo disintegration and oxidation.

11,643. Then, I think you find, do you not, some fatty matter and oil globules?—Yes, a good deal of fatty matter, that is to say, a good deal, microscopically speaking. I have not estimated the quantity; you find the fatty matter partly as oil globules and partly as crystals, owing to decomposition.

11,644. Then, I believe, you also find in the mud particles of coal and soot, do you not?—Yes, many; also fibres of paper and white fibrous tissue.

11,645. Now, with regard to these specimens of mud, is there any general conclusions that you came to with regard to the characteristics of these muds and the different sources from which they were brought?—Those near the sewers seem to be the worst, and the very worst of all was taken from a sewer; that is to say, taken from an outfall just below an Trinity Ballast Wharf.

11,646. (*Mr. Michael.*) That is the West Ham sewer outfall, is it not?—That, I am afraid, I do not know. I have it "Next to Baldwin and Hugh, London wharf."

11,647. (*Mr. Lumley Smith.*) I may ask you generally with regard to the 25 specimens that you have examined, do you find the products of sewage in all of them?—I think in all, more or less.

11,648. Those are worst that are nearest to the outfalls, but you do find indications of sewage everywhere?—Yes, even at Gravesend and Chelsea.

11,649. Now I want to ask you a question or two upon other points. What is a diatom?—A diatom is a low vegetable organism.

11,650. It is something that is alive, is it?—It is something which is alive, but it has scales composed of silica, which resist decomposition for any conceivable length of time.

11,651. Have you found fragments of diatoms in the mud?—In every specimen of mud.

11,652. I believe a gentleman of the name of Roper wrote a book upon them, did he not?—He wrote a paper upon them in the Transactions of the Royal Microscopical Society, new series, volume 2, page 567.

11,653. What I want to ask you is this; there are certain diatoms which are found in fresh water, are there not?—There are.

11,654. And some in brackish water?—Yes.

11,655. And some in sea water?—Yes.

11,656. If you get fragments of diatom you can tell whether they have come from sea water, or brackish water, or fresh water?—In many instances.

11,657. I believe Mr. Roper gives 104 species from mud off the Isle of Dogs?—Yes, 30 being marine, 29 from brackish water, and the remaining 45 being of the fresh water species.

11,658. Are you able to give us any examples of marine diatom refuse being found in the fresh water districts, and *vice versâ*?—Yes, that has been done. Mr. Roper himself makes a statement to that effect.

11,659. What is the conclusion he comes to?—At Hammersmith 29 were fresh water species out of 43, the remainder being sea water.

11,660. What were found at Gravesend?—Out of 47 specimens only eight were peculiar to fresh water.

11,661. So that they are mostly either diatoms of brackish water, or of the sea?—Yes.

11,662. The figures show that the water is of a decided salt water character up as high as Hammersmith?—Yes, 14 of them being salt water specimens.

11,663. (*Chairman.*) What is the conclusion which you draw from that?—That sea water gets up to Hammersmith, or even farther than that, to Teddington, I believe.

11,664. (*Mr. Lumley Smith.*) So that from the actual diatomaceæ you can see that the sea water has a decided effect up as far as Hammersmith, or farther?—Farther than Hammersmith, I believe.*

11,665. These creatures have silicious shells, have they not?—Yes, they have.

11,666. And they are very light?—Yes.

11,667. What becomes of them when they die?—The organic part is dissolved out; it is decomposed. The siliceous shells remain.

11,668. Do they go in any considerable amount to form the mud of the Thames?—Not to form the mud of the Thames in any considerable amount, but you would find fragments of them in any mud.

11,669. We have had some evidence given about bacteria, and questions were asked as to whether the sewage would be in any way destroyed by the bacteria. Now bacteria are not large creatures, I believe?—They are the hundred thousandth part of an inch in diameter, or less.

11,670. Are they peculiar to sewage?—By no means, they are everywhere.

11,671. With regard to human beings, are they subject to bacteria?—Everywhere; in every tissue; in the blood; in every part of the body in health and in disease.

11,672. Do you suggest that we are all full of bacteria?—I do.

11,673. Are those creatures alive?—They are, or their germs.

11,674. They are found everywhere, in the air, and in the water?—They are found everywhere, and on everything.

11,675. Then I suppose you find them in sewage, and in water, and everywhere?—Undoubtedly.

11,676. When the sewage is poured out into the Thames, I presume, from what you have said, that to a certain extent its putrefying or its decomposition is assisted by bacteria—what is your view about it—to what extent do the bacteria have any effect upon the sewage, because it is suggested that the bacteria would eat up all the sewage?—I am afraid they will not grow fast enough, particularly at this time of the year. If time were allowed, and if the temperature were sufficient for them to grow very rapidly indeed, they would decompose the sewage, and reduce it to something perfectly innocuous, but that would involve an enormous number and enormous time, and a very thin layer of the organic material spread over an enormous surface.

11,677. It is not likely to take place, as the sewage is thrown into the river now?—No; certainly not.

11,678. (*Sir John Coode.*) It is not sufficient to have any practical effect upon the sewage, as it is thrown into the river day by day?—Not practically.

(*Mr. Michael.*) I may say that there has been no suggestion of the kind upon this side of the table.

* See table at the end of Evidence.

Cross-examined by Mr. Michael.



11,679. As I understand you, your investigation has been confined to these 25 specimens of mud?—It has.

11,680. You have not examined, have you, the suspended matter in the Thames water?—I have not.

11,681. Therefore you are unable to speak to what are the living agencies at work eating up the sewage?—Except as regards the bacteria.

11,682. I do not mean bacteria—you are perfectly aware that there are much larger organisms developed in matter of an organic character, which tend to destroy it?—I was not aware of any organisms which would go up and down the Thames and destroy the sewage; but I have examined water with mud in suspension many times, and I never saw any organic beings existing in water that would be likely to destroy the suspended matter of sewage.

11,683. Did you find a large number of desmids and diatoms in the mud?—I did.

11,684. Did you find a large quantity of algæ present?—I did not find a large quantity of algæ, but some algæ.

11,685. Did you take the trouble to discover what is the nature of the superficial matter to be found on the mud?—No, the mud was brought to me in bottles, so I had not the opportunity of examining the surface.

11,686. You had not the means of examining the mud at varying depths?—No, not in this inquiry.

11,687. You made no quantitative examination at all?—No.

11,688. Did you find in your examination the hairs of oats?—Yes.

11,689. Now, a number of these vegetable matters would be found in the detritus washed into the Thames?—Yes.

11,690. For instance, the spiral vessels and the hairs of oats would be washed into the Thames along with the road detritus?—Yes, but one finds the spiral vessels and certain very stable, vegetable, and animal tissues most abundant in the sewage in the mud banks near the openings of the sewers, and no vegetables will grow there.

11,691. But there are vegetables to be found, are there not, in every specimen, that is to say, salt water and fresh water algæ?—Yes, but not of the class of algæ one finds in very fresh water streams.

11,692. Shall I put it "brackish"?—I think not.

11,693. Have you, or have you not, found algæ in the various specimens you have examined?—I found algæ, but extremely few; not nearly so many as you would find in an ordinary stream in the country.

11,694. Have you looked at the character of the mud itself in situ?—No, not upon the Thames.

11,695. Then you have not observed the slimy appearance of which we have heard?—I have not inquired into that at all.

11,696. Is it not the fact, with regard to the envelope of these spirals, that they are likely to be turned yellow through a great many other causes than passing through the intestinal canal?—I think not.

11,697. Have you ever seen spiral vessels in peaty water?—Yes. I have.

11,698. Is it not the fact that where any such pass through peaty water they become coloured in the way you describe?—Yes, but the spiral vessels found in peaty water are entirely different from those found in the mud of the Thames; many of the spiral vessels here are from the common cabbage, and they are very much larger than those found in peaty water.

11,699. You would expect that ordinary detritus would contain a very large quantity of spirals, would you not?—I should not.

11,700. Have you examined ordinary detritus?—I have, but not recently. You find some in it; there are some in straw; but the spiral vessels of straw are totally different from those of cabbage.

11,701. Have you examined the spiral vessels brought down with the sewage from the storm overflows?—No, I have not.

11,702. Are you able to say that the whole of the spiral vessels which you found in the mud were the production of sewage matter being deposited upon the banks?—I am able to say that many of the spirals I found in the mud banks came either from cabbage or from plants closely resembling cabbage, or from turnips, or from carrots, or from tea-leaves; those may be, I think, identified.

11,703. But you have no idea either how much the organic matter formed of the whole, or how much the spirals formed of the matter that you examined?—That I cannot say.

11,704. (*Sir Benson Maxwell.*) From the appearance of the spirals, could you say whether they had passed through the alimentary canal or not?—No; they may have been boiled.

11,705. We had some evidence that the spirals in passing through the alimentary canal, lose the outer envelope?—That is so.

11,706. Is it only by passing through the alimentary canal that they lose the outer envelope?—By prolonged boiling you get the same effect.

11,707. (*Dr. Stevenson.*) What would be the effect of prolonged maceration in cold water?—I think it would be the same as of passing through the alimentary canal.

11,708. (*Dr. de Chaumont.*) How do you recognise the yellow masses as being from sewage?—They have this distinctive character, that they can be broken up and squeezed between glass, and the yellow matter squeezed out, whereas the yellow matter from vegetables is usually hard and cannot be squeezed, and the yellow matter is distinct. I have frequently seen yellow matter, which I should not put down as fæcal.

11,709. Is there any chemical re-action?—No, I have not been able to get any chemical re-action, but you can tell by the eye.

11,710. If you met with iron in the form of oxide suspended, do you think that would be liable to lead you to error in respect of the colour?—I think it would be quite impossible to make any mistake of that kind, even without the chemical re-agent, because the colour and the appearance would be different, and the hardness of the material would be different. I have compared those which one calls fæcal masses in sewage with actual fæcal masses, and they look exactly alike.

11,711. (*Sir John Coode.*) You think you can detect, without any doubt or question, those vessels which have actually passed through the human body?—Musular fibre, without doubt or question, and yellow elastic tissue, without doubt or question; the other things I think not without some doubt.

Re-examined by Mr. Lumley Smith.

11,712. Although you are unable to say whether those spirals have passed or not through the alimentary canal, they have been certainly cooked?—They have been certainly cooked. Prolonged boiling would produce the same effect.

11,713. (*Dr. Stevenson.*) But you said something about maceration; would simple maceration in cold water have the same effect?—I think that the soft spiral vessels, if they were macerated a sufficiently long time in cold water, would have the spirals separated.

11,714. (*Mr. Lumley Smith.*) I think you stated you had not examined the slimy mud for the purpose of microscopic investigation?—I have not.

11,715. But you have seen the black mud?—Yes.

11,716. And you have seen it in the summer?—Yes.

*Mr. L. S. Beale, M.B., F.R.S.*

13 March 1883.

*(The witness handed in the following list of stations where the mud was taken from.)*

November 16th 1882.

Present:
W. Collingridge, Inspector Lewis, } Wind N. by E.

High water, London Bridge, 4.52.
Snow.

SAMPLE MUD.

SAMPLE of MUD taken fron Bed of RIVER.

| No. | REMARKS. |
|---|---|
| 1 | Centre of Southern Outfalls Station, Crossness, in a line with the end of the Jetties. Time. 12.45 a.m. |
| 2 | Off Crossness, about 20 feet from wall, midway between upper Jetty and upper end of River Wall. Time 12.50 a.m. |
| 3 | 100 feet above house above Powder Magazine, Half-way Point, a few yards from the shore, lower edge of the so-called Barking Bank. |

These were taken by Dr. Collingridge.
Taken to Dr. Beale.
INSPECTOR LEWIS.

November 24th 1882.

Present:
W. Collingridge, Inspector Lewis, } Wind fresh, N.W.
High water, London Bridge, 1 p.m.

SAMPLE MUD.

SAMPLES of MUD taken for DR. BEALE by W. COLLINGRIDGE.

| No. | REMARKS. |
|---|---|
| 4 | Off Erith.—Off Causeway Corinthian Yatch Club, 20 yards from shore. Time 1.26 p.m. |
| 5 | Erith.—Off Town Causeway about 30 yards from River walls. Time 1.37 p.m. |
| 6 | Erith.—Opposite Easton and Anderson's Works, about 70 feet from shore. Time 1.44 p.m. |

Taken to Dr. Beale.
INSPECTOR LEWIS.

4th December 1882.

Wind, west. Fresh. Cloudy.
High water, London Bridge, 8.30.

SAMPLES OF MUD.

Taken for DR. BEALE by INSPECTOR LEWIS.

| No. | Time. | REMARKS. |
|---|---|---|
| 7 | 2.15 | In a line of the stern of the "Cornwall" off the shore about 90 feet from edge of bank. |
| 8 | 2.25 | In a line with centre of the "Cornwall" about 50 feet or 60 feet from the edge of bank. |
| 9 | 1.15 | About 100 feet below Conservancy Causeway, Greenhithe, and about 100 feet from the shore. |
| 10 | 1.30 | About 100 feet from the Quay Centre of Ballast Wharf, by the Arethusa. |

Removed to Dr. Beale's, 5th December.

15th December 1882.

Wind, east. Very foggy.
High water London Bridge, 4.43.

SAMPLES OF MUD.

Taken for DR. BEALE by INSPECTOR LEWIS.

| No. | Time. | REMARKS. |
|---|---|---|
| 11 | 1.25 | Beckton, in a line with the Clock Tower, about 80 to 90 feet from Quay. |
| 12 | 1.35 | Barking Outfall, about 40 feet below outfall in a line with the lower corner of the station off the shelve piece. |
| 13 | 1.45 | Barking. At the lower end of the Metropolitan Board of Works Grounds, and about 100 feet from the Bank. |

Removed to Dr. Beale's 16th instant.

4th January 1883.

Wind, S.E., light.
High water, London Bridge, 9.22.

SAMPLE MUD.

Taken at GRAVESEND for DR. BEALE.

| No. | Time. | REMARKS. |
|---|---|---|
| 14 | 1.50 | Midway between the Customs Causeway and the Conservancy, about 30 feet from the River end of Causeway, nearly low water (Causeway is 160–180 feet in length). |
| 15 | 2.15 | Opposite the lower end of the "Clarendon" Hotel, in a line with the Terrace Pier Head. |
| 16 | 2.35 | Just below the Club House, about 80 feet from Coal Wharf Quay, and in a line with the end of that Quay. |

INSPECTOR LEWIS.

10th January 1883.

Wind moderate, Easterly.
High water, London Bridge, 2.27 a.m.

SAMPLE MUD.

Taken for DR. BEALE by INSPECTOR LEWIS.

| No. | Time. | REMARKS. |
|---|---|---|
| 17 | 8.0 | Crossness. At the Upper Outfall taken from the bed of the River. |
| 18 | — | From a bank at the upper end of the Upper Jetty at Crossness. |
| 19 | 9.0 | Right off the centre of Barking Outfall, about 120 feet from the arches. |
| 20 | 10.0 | At a sewer by the steps just above Woolwich Pier. |

INSPECTOR LEWIS.
Sent to Dr. Beale 10th January 1883.

11th January 1883.

Wind, S.E., light.
High Water, London Bridge, 3.?.

SAMPLE MUD.

| No. | Time. | REMARKS. |
|---|---|---|
| 21 | 11 a.m. | Taken from an outfall just below the Trinity Ballast Office, Limehouse, and next to Baldwin and Hugh London Wharf. |

INSPECTOR LEWIS.
Taken to Dr. Beale.

17th January 1883.

Wind, W., light, dull. Rain early morning.
High Water, London Bridge, 7.44.
SAMPLE MUD.

| No. | Time. | Remarks. |
|---|---|---|
| 22 | 11.40 | Taken at East Greenwich off Messrs. Rowton and Whiteway's Wharf, about 100 feet below the Harbour Master's Causeway, and about 40 to 50 feet from the Quay. |
| 23 | 2.50 | Blackwall.—At the lower side of the Upper Pier Head of the South West India Dock Blackwall entrance, about 4 feet from the pier and about 40 feet from the pier head. |

18 January 1883.

Wind, moderate, S.W., with Rain.
High Water, London Bridge, 8.53.
SAMPLE MUD.

Taken near Waterloo and Chelsea.

| No. | Time. | Remarks. |
|---|---|---|
| 24 | 1.15 | (South Shore) opposite the Saw Planing Works, about 200 or 250 feet above Charing Cross Railway Bridge, and about 100 feet off the Quay. |
| 25 | 2.15 | Chelsea, North Shore, opposite the Aquatic Stores, and about 70 feet off the Quay, and about 400 or 500 feet below Randall's Coal Wharf (near midway between Battersea Old Bridge and the Wharves Creek, Cremorne Wharf. |

Inspector Lewis.
Taken to Dr. Beal

*Mr. L. S. Beale, M.B., F.R.S.*

13 March 1883.

The witness withdrew.

*Dr. Beale* subsequently put in the following list of Diatoms found in the mud of the Thames; it is taken from a paper by Dr. Bossey, of Red Hill, and published in the proceedings of the Holmesdale Natural History Club:

A List of Fresh and Salt Water Diatoms found in Mud Banks in the River Thames, compiled for the purpose of showing the influence of the Flood and Ebb Tides in forming those Banks.

| Marine Diatoms in small capitals. Fresh Water Diatoms in ordinary type. | Half a Mile above Teddington Lock. | Teddington Cut. | One Mile below Teddington Lock. | Kew. | Blackwall. | Estuary of the Thames, Sheerness. |
|---|---|---|---|---|---|---|
| Achnanthes brevipes, *Ag.* | | | | | * | * |
| Achtinocyclus sedenarius, *Roper.* | | | | * | * | * |
| „ undulatus, *Kütz.* | | | | * | * | * |
| „ octodenarius, *W. Sm.* | | | | | | * |
| Amphitetras antediluviana, *Ehr.* | | | | * | * | * |
| Amphora ovalis, *Kütz.* | * | * | * | * | * | |
| „ minutissima, *W. Sm.* | | | * | * | | |
| Amphiprora alata, *Kütz.* | | | | | | * |
| „ vitrea, *W. Sm.* | | | | | | * |
| Biddulphia aurita, *Breb.* | | | | * | * | |
| „ Rhombus, *W. Sm.* | | | | * | | * |
| „ turgida, *W. Sm.* | | | | * | | |
| „ Bayleyii, *W. Sm.* | | | | | | * |
| „ pulchella, *Gray.* | | | | | | * |
| Campylodiscus costatus, *W. Sm.* | * | * | * | * | * | |
| „ clypeus, *Ehr.* | | | | | * | |
| „ cribrosus, *W. Sm.* | | | | | * | * |
| „ bicostatus, *W. Sm.* | | | | | * | |
| Cocconeis Pediculus, *Ehr.* | * | | * | * | * | |
| „ Placentula, *Ehr.* | * | * | * | * | * | * |
| „ scutellum, *Ehr.* | | | | | | * |
| Cocconema lanceolatum, *Ehr.* | * | * | * | * | * | |
| „ Cistula, *Ehr.* | * | * | * | | | |
| „ cymbiforme, *Ehr.* | * | | * | * | * | |
| „ parvum, *W. Sm.* | * | * | | * | | |
| Coscinodiscus minor, *Ehr.* | | | | * | * | |
| „ radiatus, *Ehr.* | | | | * | * | * |
| „ eccentricus, *Ehr.* | | | | * | | * |
| „ oculus iridis | | | | | | * |
| Cyclotella Kützingiana, *Thw.* | * | | | * | * | * |
| Cymbella Ehrenbergii, *Kütz.* | * | | * | * | * | |
| „ cuspidata, *Kütz.* | * | | | * | | |
| Cymatopleura Solea, *W. Sm.* | * | * | * | * | * | |
| „ apiculata, *W. Sm.* | * | * | * | * | * | |
| „ elliptica, *W. Sm.* | * | * | * | * | * | |
| Diatoma vulgare, *Bory.* | * | * | * | * | * | |
| Doryphora amphiceros, *Kütz.* | | | | * | * | * |
| „ Boëkii, *W. Sm.* | | | | | * | |
| Encyonema prostratum, *Ralfs.* | * | * | | | * | |
| „ cespitosum, *Kütz.* | | | | | * | |
| Epithemia turgida, *W. Sm.* | * | * | * | * | * | * |
| „ Argus, *W. Sm.* | * | | | * | * | |
| „ constricta, *W. Sm.* | | | | | | * |
| „ gibba, *Kütz.* | * | | | * | * | |
| „ musculus, *Kütz.* | | | | | * | |
| „ ventricosa, *Kütz.* | | | * | | | |
| Eupodiscus Argus, *Ehr.* | | | | | * | * |
| „ sculptus, *W. Sm.* | | | | | * | * |
| „ radiatus, *Bail.* | | | | | * | * |
| Fragillaria capucina, *Desm.* | | | | * | * | |
| „ virescens, *Ralfs.* | | | | * | | |
| Gomphonema constrictum, *Ehr.* | * | | | * | * | * |
| „ capitatum, *Ehr.* | * | | | | | |
| „ acuminatum, *Ehr.* | * | | | * | * | |
| „ cristatum, *Ralf.* | | | | | * | |
| „ olivaceum, *Ehr.* | * | | | * | | |
| „ curvatum, *Kütz.* | * | | | * | * | |
| „ dichotomum, *Kütz.* | * | | | | | |
| „ marinum, *W. Sm.* | | | | | * | |

| Marine Diatoms in small capitals. Fresh Water Diatoms in ordinary type. | Half a Mile above Teddington Lock. | Teddington Cut. | One Mile below Teddington Lock. | Kew. | Blackwall. | Estuary of the Thames, Sheerness. |
|---|---|---|---|---|---|---|
| Isthmia enervis, *Ehr* | | | | * | * | |
| Melosira varians, *Ag.* | | * | * | * | * | |
| „ nummuloides, *Kütz.* | | | | | * | * |
| Meridion circulare, *Ag.* | * | | * | | * | |
| Navicula Amphisbœna | * | * | * | * | * | |
| „ cuspidata, *Kütz.* | * | * | * | * | * | |
| „ abrupta, *Greg.* | | | | | | * |
| „ humerosa, *De Breb.* | | | | | | * |
| „ rhyncocephala, *Kütz.* | * | | | | | |
| „ firma, *Kütz.* | * | * | * | | * | |
| „ ovalis, *W. Sm.* | * | | | | | |
| „ Smithii, *De Breb.* | | | | | * | * |
| „ Jennerii, *W. Sm.* | | | | * | * | * |
| „ affinis, *Ehr.* | * | | | | | |
| „ tumida, *W. Sm.* | * | | * | * | | |
| „ gibberula, *Kütz.* | * | * | * | * | * | |
| „ amphirhynchus, *Ehr.* | * | | * | * | | |
| „ ambigua, *Ehr.* | * | * | * | * | * | |
| „ subsalina, *Donkin.* | | | | * | * | |
| „ sphœrophora, *Kütz.* | * | | * | | | |
| „ punctulata (Marina), *W. Sm.* | | | | | * | * |
| „ dicephala, *Kütz.* | * | | | * | | |
| „ Didyma, *Kütz.* | | | | | * | * |
| „ Entomon, *Ehr.* | | | | | * | * |
| „ interrupta, *Kütz.* | | | | | * | |
| „ Lyra, *Ehr.* | | | | | | * |
| „ Hennedii, *W. Sm.* | | | | | * | |
| „ Bombus, *Ehr.* | | | | * | * | * |
| „ convexa, *W. Sm.* | | | | | * | * |
| „ Crabo, *Ehr.* | | | | | | * |
| „ rhomboides, *Ehr.* | * | | | | | |
| Nitzschia sigmoidea, *W. Sm.* | * | * | * | * | * | |
| „ curvula | | * | | | | |
| „ birostrata | | | | | | * |
| „ amphioxys, *W. Sm.* | * | | | * | | |
| „ Brebissonii | * | | * | | | |
| „ Sigma, *W. Sm.* | | | | * | | * |
| „ dubia, *W. Sm.* | | | | | * | |
| Odontidium mutabile, *W. Sm.* | * | | * | * | | |
| „ Tabellaria, *W. Sm.* | * | | * | * | | |
| Orthosira arenaria, *W. Sm.* | * | * | * | * | * | * |
| „ marina, *W. Sm.* | | | | | * | |
| Pinnularia nobilis, *Ehr.* | | | * | * | * | |
| „ major, *W. Sm.* | * | | * | * | | |
| „ viridis, *W. Sm.* | * | * | * | * | | |
| „ perigrina, *Ehr.* | | | | | | * |
| „ distans, *W. Sm.* | | | | | * | * |
| „ viridula, *W. Sm.* | * | | | * | * | |
| „ mesolepta, *Ehr.* | | | | | * | |
| „ oblonga, *W. Sm.* | * | | * | * | * | |
| „ radiosa, *W. Sm.* | * | * | * | | * | |
| „ stauroneiformis, *W. Sm.* | * | | | | | |
| „ gibba, *Ehr.* | * | * | | | * | |
| „ Cyprinus, *Ehr.* | | | | | | * |
| Pleurosigma Fasciola, *W. Sm.* | | | | | | * |
| Pleurosigma attenuatum, *W. Sm.* | * | * | * | * | * | * |
| „ Spencerii, *W. Sm.* | * | | | * | | |
| „ formosum, *W. Sm.* | | | | | * | |
| „ quadratum, *W. Sm.* | | | | | * | * |
| „ angulatum, *W. Sm.* | | | | | * | * |
| Pleurosigma Æstuarii, *W. Sm.* | | | | | * | * |
| „ Balticum, *W. Sm.* | | | | | * | |
| „ littorale, *W. Sm.* | | | | | * | |
| „ Hippocampus, *W. Sm.* | | | | | | * |
| „ strigosum, *W. Sm.* | | | | | | * |
| „ distortum, *W. Sm.* | | | | | | * |
| Podosira hormoides, *Kütz.* | | | | * | | |

*Mr. L. S. Beale, M.B., F.R.S.*

13 March 1883.

Marine Diatoms in small capitals.

Fresh Water Diatoms in ordinary type.

| | Half a Mile above Teddington Lock. | Teddington Cut. | One Mile below Teddington Lock. | Kew. | Blackwall. | Estuary of the Thames, Sheerness. |
|---|---|---|---|---|---|---|
| RHABDONEMA ARCUATUM, *Kütz.* | | | | | | * |
| Surirella biseriata *De Breb.* | * | * | * | * | * | * |
| „ splendida, *Kütz.* | * | * | * | * | * | |
| „ STRIATULA, *Turp.* | | | | * | * | * |
| „ GEMMA, *Ehr.* | | | | * | * | * |
| „ FASTUOSA, *Ehr.* | | | | | * | |
| „ BRIGHTWELLII, *W. Sm.* | | | | * | * | |
| „ linearis, *W. Sm.* | * | | | | | |
| „ ovata, *Kütz.* | * | * | * | * | | * |
| SCHIZONEMA CRUCIGER, *W. Sm.* | | | | | * | |
| Stauroneis Phenicenteron, *Ehr.* | * | | * | * | * | |
| „ gracilis, *Ehr.* | * | | * | | | |
| „ SALINA, *W. Sm.* | | | | | | * |
| „ acuta, *W. Sm.* | * | * | | * | | |
| „ PULCHELLA, *W. Sm.* | | | | * | * | * |
| Synedra radians, *W. Sm.* | * | * | | * | | |
| „ ulna B., *Ehr.* | | | * | | | |
| „ obtusa, *W. Sm.* | | | | * | | |
| „ capitata, *Ehr.* | * | * | | * | * | |
| „ SALINA, *W. Sm.* | | | | | | * |
| „ TABULATA, *Kütz.* | | | | | | * |
| Triblionella marginata | * | * | | * | * | * |
| „ PUNCTATA, *W. Sm.* | | | | * | * | * |
| „ ACUMINATA, *W. Sm.* | | | | | | * |
| „ gracilis, *W. Sm.* | * | * | * | | | |
| „ agustata, *W. Sm.* | * | | * | | | |
| TRICERATIUM FAVUS, *Ehr.* | | | | * | * | * |
| „ STRIOLATUM, *Ehr.* | | | | * | * | * |
| „ ALTERNANS, *Bail.* | | | | | * | * |

SUMMARY.

| | Half a Mile above Teddington Lock. | In Teddington Cut. | One Mile below Teddington Lock. | Between Richmond and Twickenham.† | Kew. | Blackwall. | Estuary of the Thames. |
|---|---|---|---|---|---|---|---|
| Ebb Tide runs ⟩⟩⟩

where you took the samples, and how it was done?—Yes.

11,737. (*Mr. Michael.*) Did you take them in the same manner as the last witness?—Yes.

11,738. (*Mr. Balfour Browne.*) Did you take them in exactly the same way?—Yes.

11,739. This diagram corresponds with Professor Way's description.

*Mr. F. J. Short.*
13 March 1883.

Cross-examined by Mr. Michael.

11,740. This sample was taken at high water, was it not?—They were taken at high water, and low water.

11,741. How did you manage at low water?—They were taken in the same positions as they are shown there, the river was divided into four parts.

11,742. (*Sir Benson Maxwell.*) How did you know when it was high water, or low water when you took the samples?—We moored the boat to a dolphin of the pier, and scratched marks upon one of the piles until the water lowered no more in the case of low water, and rose no more in the case of high water. There was then slack water for a short time, and it was during that time the samples were taken.

11,743. (*Mr. Michael.*) What was the depth at which you took the samples at low water?—At 20 feet, in the middle of the river.

11,744. Was that 20 feet at each of these points?—No, only in the middle of the river. I do not know what the depth at the other places was, but they were taken about a foot from the bottom.

11,745. How do you know where the samples were taken as regards the bottom of the river?—Because I had a heavy weight which I lowered to the bottom.

11,746. Until it touched the bottom?—Yes.

11,747. How long afterwards did you take the sample?—The sample was taken at the same time; the bottle was lowered upon the string, with a cord tied to the stopper.

11,748. (*Sir Benson Maxwell.*) You would strike the bottom with the lead?—It did not *strike* the bottom; it was lowered quietly on to it.

11,749. And that would disturb the mud, would it not?—I do not know whether it would.

11,750. That would depend upon the solidity of the mud?—But the bottle being a foot, or a foot and a half above the surface of the mud, I do not know whether it would in any way affect the samples.

11,751. (*Mr. Michael.*) How long did it take to take the samples?—They were taken in a quarter of an hour.

*Mr. Michael* stated that he wished to have evidence about the taking of samples at Gravesend and Southend, and that he only wished to know how the water was collected, the absolute position from which the water was taken, and the time occupied in taking the samples.

The witness withdrew.

Dr. Collingridge called in and examined.

11,752. (*Mr. Michael.*) What interval elapsed between the various times of taking the waters?—In no case except Southend more than a quarter of an hour between the first samples, and the last.

11,753. But how many samples were taken at Gravesend?—At Gravesend there were three samples taken.

11,754. (*Sir John Coode.*) Were you present when they were taken?—I was not.

11,755. (*Mr. Lumley Smith.*) You are speaking from each label which had the time upon it, at which it was taken, so that a comparison of the labels would enable you to judge of the interval of time between taking the first sample, and the last of the section?—Yes, I can speak to that, and in no case with the exception of Southend was the time occupied in taking the samples, more than 15 minutes in each place.

11,756. (*Mr. Michael.*) How many boats were there employed at Gravesend?—There was one boat manned by two men.

*Dr. Collingridge.*

11,757. Is it possible that those specimens could have been taken in 15 minutes?—Yes, because the men only had to row half across the river.

(*Sir John Coode.*) How many specimens were taken?

(*Mr. Michael.*) Six specimens, three were taken at 20 feet below the surface, and three at the surface.

(*Witness.*) The river is divided into four different divisions, so that there are three spaces.

*The witness explained to the Commissioners upon the diagram that it would be exactly half of the river that would have to be crossed.*

The witness withdrew.

Mr. Baldwin Latham, Mem. Inst. C.E., re-called and further examined.

11,758. (*Mr. Lumley Smith.*) Will you refer to that part of your examination at which certain tables were promised?—It was put to me in cross-examination that instead of there being 10 parts of chlorine in 100,000 parts in sewage there were 20, and I then stated that it would make very little difference indeed with regard to the mixing action; but I promised to work out the result at 20 parts and put the tables in. I have prepared them in the same form, and beg to hand them in. Practically in the way in which I have dealt with it (I have put the results into two small tables, A. and B.) (*These were handed in, and are as follows.*)

*Mr. B. Latham, M. Inst. C.E.*

*Mr. B. Latham, M. Inst. C.E.*

13 March 1883.

## A.

TABLE showing the EFFECT of the MIXING ACTION in the RIVER THAMES.

Time occupied by Fresh Water and Sewage in traversing River.

The results are obtained by taking sewage as containing 10, river water 1·7, and sea water 1961 parts of chlorine in 100,000 parts. In this case the upland water is apportioned to every section of the river which it enters.

| | September 14th. | | | September 22nd. | | | November 30th. | | |
|---|---|---|---|---|---|---|---|---|---|
| | High Water. | Low Water. | Mean. | High Water. | Low Water. | Mean. | High Water. | Low Water. | Mean. |
| | days. | days. | days. | days. | days. | days. | days. | days. | days. |
| Teddington to Chiswick | 2·38 | ·72 | 1·55 | 1·18 | ·53 | ·85 | ·40 | ·20 | ·30 |
| Chiswick to St. Paul's Pier | 5·61 | 1·83 | 3·72 | 3·22 | 1·49 | 2·36 | 1·02 | ·39 | ·70 |
| St. Paul's Pier to Deptford | 4·56 | 1·90 | 3·23 | 2·85 | 1·57 | 2·21 | ·93 | ·36 | ·65 |
| Deptford to N. Woolwich | 6·52 | 3·37 | 4·94 | 4·19 | 2·78 | 3·48 | 1·50 | ·64 | 1·07 |
| N. Woolwich to Barking | 2·47 | 1·38 | 1·93 | 1·61 | 1·15 | 1·38 | ·61 | ·28 | ·44 |
| Barking to Crossness | 3·78 | 2·14 | 2·96 | 2·64 | 1·86 | 2·23 | 1·08 | ·52 | ·80 |
| Crossness to Erith | 3·88 | 2·60 | 3·24 | 2·89 | 2·25 | 2·56 | 1·29 | ·70 | 1·00 |
| Erith to Gravesend | 12·70 | 11·33 | 12·02 | 10·37 | 9·48 | 9·93 | 12·57 | 11·75 | 12·16 |
| Gravesend to Southend | 12·03 | 20·15 | 16·09 | 12·71 | 14·46 | 13·58 | | | |
| Total | 53·93 | 45·42 | 49·68 | 41·66 | 35·55 | 38·60 | 19·40 | 14·84 | 17·12 |
| Deptford to Southend | 41·38 | 40·97 | 41·18 | 34·41 | 31·96 | 33·18 | 17·05 | 13·89 | 15·47 |

## B.

TABLE showing the EFFECT of the MIXING ACTION in the RIVER THAMES.

Time occupied by Fresh Water and Sewage in traversing River.

The results are obtained by taking Sewage as containing 20, river water 1·7, and sea water 1961 parts of chlorine in 100,000 parts. In this case the upland water is apportioned to every section of the river which it enters.

| | September 14th. | | | September 22nd. | | | November 30th. | | |
|---|---|---|---|---|---|---|---|---|---|
| | High Water. | Low Water. | Mean. | High Water. | Low Water. | Mean. | High Water. | Low Water. | Mean. |
| | days. | days. | days. | days. | days. | days. | days. | days. | days. |
| Teddington to Chiswick | 2·38 | ·72 | 1·55 | 1·18 | ·53 | ·85 | ·40 | ·20 | ·30 |
| Chiswick to St. Paul's Pier | 5·61 | 1·83 | 3·72 | 3·22 | 1·49 | 2·36 | 1·02 | ·39 | ·70 |
| St. Paul's Pier to Deptford | 4·56 | 1·90 | 3·23 | 2·85 | 1·57 | 2·21 | ·93 | ·36 | ·65 |
| Deptford to N. Woolwich | 6·52 | 3·37 | 4·94 | 4·19 | 2·78 | 3·48 | 1·50 | ·64 | 1·07 |
| N. Woolwich to Barking | 2·47 | 1·38 | 1·93 | 1·61 | 1·15 | 1·38 | ·61 | ·28 | ·44 |
| Barking to Crossness | 3·78 | 2·14 | 2·96 | 2·64 | 1·86 | 2·25 | 1·08 | ·52 | ·80 |
| Crossness to Erith | 3·88 | 2·60 | 3·24 | 2·89 | 2·23 | 2·56 | 1·29 | ·70 | 1·00 |
| Erith to Gravesend | 12·70 | 11·34 | 12·02 | 10·37 | 9·48 | 9·93 | No samples taken at Gravesend. | | |
| Gravesend to Southend | 12·04 | 20·16 | 16·10 | 12·71 | 14·47 | 13·59 | 12·57 | 11·75 | 12·16 |
| Total | 53·94 | 45·44 | 49·69 | 41·66 | 35·56 | 38·61 | 12·40 | 14·84 | 17·12 |
| Deptford to Southend | 41·39 | 40·99 | 41·19 | 34·41 | 31·97 | 33·19 | 17·05 | 13·89 | 15·47 |

I find, taking the number of days required for the sewage to pass out of the river, that it only makes a difference in some instances in the second place of decimals. Upon the 14ih of September at high water, taking the whole distance from Deptford to Southend with 10 parts, it would be 41·38 days and with 20 parts it would be 41·39 days. And the same at low water, you have a result of 40·97, which becomes 40·99, that is taking the 14th of September; and so with regard to all the rest of the days. There is another point I should like to mention, which I omitted at the time, and that is with regard to the solid matter. I am referring now to my answer to question 8064. All I wish to state is this, that the solid matter which I was speaking of with regard to the sewage, the 200,000 tons a year passing into the Thames is absolutely dry matter. But that is compared with the saltings of the river which are taken out in cube yards, and calculated that a cube yard in its natural state would weigh a ton. We are here comparing dry matter with matter which contains 40 per cent. of water; so that the absolute dry matter in the saltings would be very much less than 41,417 tons, and the ratio of the dry matter of the sewage would be very much greater; and would be more than six times as much as the dry matter of the saltings.

The witness withdrew.

SIR P. BENSON MAXWELL TOOK THE CHAIR.



Professor W. H. CORFIELD, M.D., called in and examined.

11,759. (*Mr. Balfour Browne.*) You are Professor of Hygiene at University College?—I am.

11,760. And you are Doctor of Medicine of Oxford and an Examiner at Cambridge?—Yes.

11,761. Have you examined the condition of the lower Thames and the outfalls of the metropolitan sewers?—I have.

11,762. Do you remember the date when you made your examination?—It was in 1878, on October 16th, I think.

11,763. It was shortly, I think, after the sinking of the "Princess Alice"?—Yes, the "Princess Alice" went down upon the 3rd September.

11,764. The sewer outfalls at the time of your inspection were discharging, were they not, into the river?—Yes.

11,765. Both at Barking and Crossness?—Yes, at both places.

11,766. And on those occasions when you inspected, which way was the sewage flowing?—The sewage was flowing up stream.

11,767. Both from Barking and Crossness?—Yes.

11,768. From Crossness did you follow the stream of sewage?—Yes, I followed it in a boat for about three quarters of a mile.

11,769. Was the sewage marked distinctly upon the surface of the river?—It was.

11,770. What by?—By the floating material upon the surface of the water.

11,771. Was the stench bad at either of the outfalls upon that day?—It was very bad indeed at both the outfalls.

11,772. Did you take samples and specimens in several parts of the river near the outfalls?—Yes, those samples are deposited in the Parkes Museum of Hygiene in Margaret Street, Regent Street.

11,773. As a matter of fact the Museum is not opened to the public at present, but it is to be?—It is to be.

11,774. Did you also take a sample in mid-stream off Woolwich?—I took one sample in mid-stream off South Woolwich.

11,775. Do you remember the time at which the water was collected?—At a little after 12 o'clock, I think.

11,776. You took another sample at Barking?—Yes, I took another sample 100 yards above the Barking outfall at about 5 o'clock in the afternoon.

11,777. Do you recollect the character of the sample collected off Woolwich which you have just spoken about?—It was a highly polluted water.

11,778. Generally, do you recollect how many parts of albumenoid ammonia per 100,000 parts?—0·2, that is to say, a tenth of what there is in sewage.

11,779. Then with reference to the sample that was collected at the Northern outfall, did that consist largely of sewage?—Yes, that contained, if I remember rightly, about 4½ parts of ammonia per 100,000 parts; that is to say, of saline ammonia, not albumenoid ammonia.

11,780. Going back to the South Woolwich specimen, how much suspended matter did that contain?—It contained seven parts per 100,000 of suspended matter, of which 80 per cent. were fixed and 20 per cent. volatile.

11,781. (*Prof. Williamson.*) When you say "fixed" do you mean at 100° centigrade, or do you mean not combustible?—I mean, that on incineration, 80 parts remained that were not volatile. The Barking specimen contained 14·65 parts of suspended matters, of which 40 per cent. were fixed and 60 per cent. volatile.

11,782. (*Mr. Balfour Browne.*) The comparison of the South Woolwich sample with the Barking sample gives you an idea of the condition of the river there as compared with it at Barking where the sewage was being poured in?—Yes.

11,783. Have you taken up samples of mud from various parts?—I inspected the mud at various points. I did not take any away with me.

11,784. What was its character?—It was in most places black, and very foul.

11,785. (*Prof. Williamson.*) Did you notice any sliminess in the mud which you raised from the bottom, or was it loose particles?—Most of it was very slimy.

11,786. (*Mr. Balfour Browne.*) Did you also inquire into the circumstances of some cases of illness?—I did.

11,787. What were they due to?—They were due to the immersion in the water of the Thames at the time of the accident to the "Princess Alice."

11,788. What did you make out of your inquiries into those cases?—

11,789. (*Chairman.*) Did you see the patients yourself?—I did not in either instance.

11,790. (*Sir John Coode.*) Nor the clothing, because we have heard much about the clothes?—I did not; those were cases that came under my notice, and I inquired into the circumstances from their friends and from the medical men who attended them; in one case seven persons were immersed, of whom three were saved, and of these two were taken ill, one, the father, slightly, the other, a boy, five years of age, badly, with what was considered to be a form of pneumonia accompanied with a little diarrhœa, but was believed from the symptoms not to be typhoid fever. The doctor who was attending the case thought that it was not a case of typhoid fever, but the fact was that the nurse who was attending the patient contracted typhoid fever, and died of it. Another case was that of a young lady who was in the water about four or five minutes, when she was rescued by a boat, and then taken to a cottage and put to bed while her clothes were dried. On the 4th September, the day after the accident, she went home and went to bed, suffering from great exhaustion; she remained in bed until about October the 7th, suffering from a form of pneumonia. At the end of the first week of her illness, her temperature rose to 103, and remained at this height continuously for a week, going occasionally up to 105; and she was attacked with severe diarrhœa and became delirious. Those are very obvious symptoms of typhoid fever, Altogether she was in bed about a month. Although the eruption was not observed either in this or in the previous case, I am of opinion that they were both cases of typhoid fever, produced by the water swallowed at the time of immersion; indeed, the description of the latter case is very characteristic of a large number of cases of typhoid fever, accompanied with pneumonia, and in the former case, although the symptoms of pneumonia were most prominent, the fact that the nurse who attended it took typhoid fever, and died of it, is at least a very significant one.

11,791. (*Mr. Balfour Browne.*) The latter case has evidently been very carefully observed by medical men, because the temperature has been observed by them?—Yes; the medical man who attended the latter case is of opinion that it was typhoid fever.

11,792. (*Chairman.*) Who was the medical man who gave you that information?—The medical man was a doctor in Exeter; this lady went home to Exeter, and was attended there.

11,793. (*Mr. Balfour Browne.*) Have you, with the view of ascertaining whether the state of the river produces any effect upon the health of the population upon the banks of the lower Thames, examined the quarterly returns of the Registrar-General?—Yes, I have.

11,794. For how many years?—For 11 years.

11,795. Which years are those?—Those are from 1871 to 1881 inclusive.

11,796. For what district?—For certain sub-districts

*Prof. W. H. Corfield, M.D.*

13 March 1883.

or parts of sub-districts from London Bridge downwards to the Medway, on opposite sides.

11,797. Have you made out tables which you are now going to submit to the Commission?—Yes. (*See Appendix* B.U.)

11,798. You have compiled those tables from the Registrar-General's returns?—Yes, I have.

11,799. What does Table I. show?—That consists of 8 sheets, and it gives the deaths every quarter; it shows the mortality statistics, generally speaking, especially from zymotic diseases, for each quarter during the 11 years in each of the eight districts or sub-districts on the north side of the Thames.

11,800. (*Mr. Michael.*) Will you read the names of the districts?—Beginning with London Bridge upon the north, the districts are a part of Whitechapel, called Aldgate; that includes part of Whitechapel, East Smithfield, Old Tower, Tower Without, and the Tower of London.

11,801. (*Chairman.*) Then there are Limehouse, Poplar, West Ham, East Ham, Barking, Romford, Rainham, Grays, and Thurrock?—Whitechapel is the first; the second is St. George's-in-the-East.

11,802. (*Mr. Balfour Browne.*) What you have read, sir, are the Local Board districts. (*To the witness.*) Your districts are Aldgate, St. Paul, Stepney, Poplar, West Ham, Barking Town, Hornchurch, and Orsett?—Yes, some of those are the Registrar-General's sub-districts, and some of them are the parts of those sub-districts near the river.

11,803. You are trying to find out whether this condition of the river has any effect upon health?—Yes.

11,804. Table II. gives similar results for the south side of the river, does it not?—Yes. That table includes the sub-districts or parts of sub-districts of St. Olave's Southwark, Greenwich, Woolwich, Bexley, Dartford, Northfleet, Gravesend, and Hoo.

11,805. What do Tables Nos. 3 and 4 show?—Tables Nos. 3 and 4 show the annual results for the same districts. (*These are incorporated in the foregoing.*)

11,806. Table No. 3 corresponding with the northern districts, and Table No. 4 with the southern districts?—Yes.

11,807. What do Tables Nos. 5 and 6 show?—Tables Nos. 5 and 6 show the average annual number of deaths from zymotic diseases in each of those sub-districts for the 10 years 1871 to 1880.

11,808. That is both for the north and for the south side of the Thames?—Table No. 5 is for the north, and Table No. 6 is for the south side of the Thames.

11,809. Your next Tables are Nos. 7 and 8?—Yes. (*These were handed in and are as follows*):

TABLE VII.

Zymotic Deaths, Average Annual Results for 10 years 1871–80. Proportions to 1,000 persons living.

North Side of the Thames.

| — | District. | Smallpox. | Measles. | Scarlet Fever. | Diphtheria. | Whooping Cough. | Fever. | Diarrhœa. | Cholera. | Zymotic Death Rate. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Aldgate | 0·42 | 0·46 | 0·66 | 0·04 | 0·82 | 0·40 | 1·27 | 0·04 | 4·11 |
| 2 | St. Paul | 0·17 | 0·73 | 0·58 | 0·10 | 1·17 | 0·37 | 1·12 | 0·03 | 4·27 |
| 3 | Stepney | 0·30 | 0·74 | 0·82 | 0·11 | 1·02 | 0·35 | 1·22 | 0·04 | 4·60 |
| 4 | Poplar | 0·46 | 0·68 | 0·85 | 0·08 | 0·91 | 0·37 | 1·06 | 0·04 | 4·45 |
| 5 | West Ham | 0·57 | 0·40 | 0·75 | 0·06 | 0·58 | 0·30 | 1·02 | 0·04 | 3·72 |
| 6 | Barking Town | 0·35 | 0·26 | 0·90 | 0·06 | 0·43 | 0·29 | 0·77 | 0·06 | 3·12 |
| | Dagenham comes in here, *see* Table XI. | | | | | | | | | |
| 7 | Hornchurch* | 0·12 | 0·24 | 0·33 | 0·12 | 0·40 | 0·32 | 0·80 | 0·02 | 2·35 |
| 8 | Orsett | 0·16 | 0·29 | 0·55 | 0·16 | 0·41 | 0·56 | 0·58 | 0·06 | 2·77 |
| | London | 0·46 | 0·51 | 0·60 | 0·12 | 0·82 | 0·37 | 0·92 | 0·04 | 3·84 |
| | Eastern Registration Division including the Counties of Essex, Suffolk, Norfolk | 0·18 | 0·17 | 0·40 | 0·11 | 0·43 | 0·35 | 0·72 | 0·02 | 2·38 |

*N.B.—This sub-district chiefly consists of places at a considerable distance from the river.

TABLE VIII.

Zymotic Deaths, Average Annual Results for 10 years 1871–80. Proportions to 1,000 persons living.

South Side of the Thames.

| — | District. | Smallpox. | Measles. | Scarlet Fever. | Diphtheria. | Whooping Cough. | Fever. | Diarrhœa. | Cholera. | Zymotic Death Rate. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | St. Olave, Southwark | 0·26 | 0·59 | 0·81 | 0·18 | 1·08 | 0·40 | 1·07 | 0·07 | 4·46 |
| 2 | Greenwich | 0·57 | 0·48 | 0·53 | 0·11 | 0·65 | 0·43 | 0·89 | 0·03 | 3·69 |
| 3 | Woolwich | 0·12 | 0·55 | 0·61 | 0·19 | 0·61 | 0·36 | 0·73 | 0·50 | 3·22 |
| 4 | Bexley* | 0·08 | 0·25 | 0·55 | 0·08 | 0·36 | 0·31 | 0·54 | 0·03 | 2·20 |
| 5 | Dartford | 0·41 | 0·38 | 0·53 | 0·19 | 0·35 | 0·25 | 0·59 | 0·07 | 2·77 |
| 5 | Northfleet | 0·40 | 0·38 | 0·88 | 0·10 | 0·40 | 0·49 | 0·74 | 0·04 | 3·43 |
| 7 | Gravesend | 0·20 | 0·22 | 0·67 | 0·05 | 0·52 | 0·36 | 0·80 | 0·06 | 2·88 |
| 8 | Hoo | 0· | 0·09 | 0·12 | 0· | 0·37 | 0·98 | 0·92 | 0·15 | 2·63 |
| | London | 0·46 | 0·51 | 0·60 | 0·12 | 0·82 | 0·37 | 0·92 | 0·04 | 3·84 |
| | South-Eastern Registration Division, including the Counties of Surrey, Kent, Sussex, Hampshire, Berkshire | 0·10 | 0·24 | 0·31 | 0·14 | 0·37 | 0·33 | 0·62 | 0·02 | 2·13 |

*N.B.—This sub-district largely consists of places at a considerable distance from the river.

11,810. Do they give the average death rate from each of the zymotic diseases and from them altogether per 1,000 persons living in the same 10 years?—Yes.

11,811. Do they show anything else?—Yes, they also show a corresponding number for London and for the registration divisions of England in which the sub-districts or districts are.

11,812. So that now you have the means of comparing the death-rate of those places with London and with the registration divisions to which they belong respectively?—Yes, with the eastern registration division, including the counties of Essex, Suffolk, and Norfolk, and with the south-eastern registration division, including the counties of Surrey, Kent, Sussex, Hampshire and Berkshire.

11,813. Now with regard to Tables Nos. 9 and 10, what do they show?—They show the density of population in 1871 and in 1881 in each of those districts, on both sides of the Thames. (*These were handed in and are as follows*):—

TABLE IX.

DENSITY of POPULATION in 1871 and in 1881, NORTH SIDE of the THAMES.

| | District. | Area in Acres. | Population, 1871. | Population to each Acre, 1871. | Population, 1881. | Population to each Acre, 1881. |
|---|---|---|---|---|---|---|
| 1 | Aldgate - - | 87 | 9,224 | 106·0 | 6,092 | 70·0 |
| 2 | St. Paul - - | 84 | 21,350 | 254·1 | 20,620 | 245·4 |
| 3 | Stepney - - | 462 | 57,690 | 124·8 | 58,500 | 126·6 |
| 4 | Poplar - - | 2,335 | 116,376 | 49·8 | 156,525 | 67·0 |
| 5 | West Ham - | 7,051 | 44,642 | 6·3 | 101,024 | 14·3 |
| 6 | Barking Town - | 3,814 | 6,576 | 1·72 | 9,155 | 2·4 |
| 7 | Hornchurch - | 19,482 | 6,979 | 0·36 | 7,196 | 0·37 |
| 8 | Orsett - - | 41,167 | 13,172 | 0·32 | 16,356 | 0·40 |
| | London - - | 75,362 | 3,254,260 | 43·2 | 3,814,571 | 50·6 |
| | Eastern Registration Division. | 3,211,441 | 1,218,728 | 0·38 | 1,342,923 | 0·42 |

TABLE X.

DENSITY of POPULATION in 1871, and in 1881, SOUTH SIDE of the THAMES.

| | District. | Area in Acres. | Population, 1871. | Population to each Acre, 1871. | Population, 1881. | Population to each Acre, 1881. |
|---|---|---|---|---|---|---|
| 1 | St. Olave, Southwark. | 1,268 | 89,902 | 70·9 | 102,646 | 80·9 |
| 2 | Greenwich - | 3,426 | 100,600 | 29·4 | 131,264 | 38·3 |
| 3 | Woolwich - | 6,500 | 73,380 | 11·3 | 80,782 | 12·4 |
| 4 | Bexley - - | 12,541 | 19,566 | 1·6 | 24,137 | 1·9 |
| 5 | Dartford - | 16,968 | 16,466 | 0·97 | 22,239 | 1·3 |
| 6 | Northfleet - | 20,176 | 10,474 | 0·52 | 12,728 | 0·63 |
| 7 | Gravesend - | 1,256 | 21,265 | 16·9 | 23,375 | 18·6 |
| 8 | Hoo - - | 19,859 | 3,143 | 0·16 | 3,397 | 0·17 |
| | London - - | 75,362 | 3,254,260 | 43·2 | 3,814,571 | 50·6 |
| | South-Eastern Registration Division. | 3,994,431 | 2,167,726 | 0·54 | 2,486,151 | 0·62 |

11,814. And also in London?—And also in London, and also in the eastern registration division for comparison with the north side of the Thames, and the south-eastern registration division for comparison with the south side of the Thames.

11,815. Then you have also Table No. 11 which shows the corresponding figures with regard to Dagenham?—Yes. (*The same were handed in and is as follows*):—

TABLE XI.

ZYMOTIC DEATHS.

Numbers for 11 years, 1871-81. 6 × N, Sub-district, 180, Romford.

Division, Romford.
Place Dagenham, Population 1871, 2,879—1881, 3,411.

| Year. | Smallpox. | Measles. | Scarlet Fever. | Diphtheria. | Whooping Cough. | Fever. | Diarrhœa. | Cholera. | Zymotic Total. |
|---|---|---|---|---|---|---|---|---|---|
| 1871 - | 6 | 1 | 1 | 0 | 2 | 2 | 3 | 0 | 15 |
| 1872 - - | 1 | 0 | 0 | 0 | 2 | 2 | 5 | 0 | 10 |
| 1873 - | 0 | 0 | 0 | 0 | 2 | 2 | 7 | 0 | 11 |
| 1874 - - | 0 | 1 | 0 | 1 | 1 | 0 | 5 | 0 | 8 |
| 1875 - | 0 | 0 | 10 | 0 | 2 | 1 | 1 | 0 | 14 |
| 1876 - - | 0 | 0 | 10 | 0 | 2 | 0 | 3 | 0 | 15 |
| 1877 - | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 3 |
| 1878 - - | 0 | 0 | 2 | 0 | 1 | 1 | 5 | 0 | 9 |
| 1879 - | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |
| 1880 - - | 0 | 0 | 4 | 0 | 1 | 0 | 2 | 0 | 7 |
| 1881 - | 0 | 6 | 0 | 0 | 2 | 3 | 3 | 0 | 14 |

ZYMOTIC DEATHS.

Average Annual Numbers for ten years, 1871-80.

| Smallpox. | Measles. | Scarlet Fever. | Diphtheria. | Whooping Cough. | Fever. | Diarrhœa. | Cholera. | Zymotic Total. | Zymotic Death-Rate. |
|---|---|---|---|---|---|---|---|---|---|
| 0·7 | 0·3 | 2·9 | 0·2 | 1·4 | 0·8 | 3·1 | 0 | 9·4 | — |

Average Annual results for ten years, 1871-80. Proportions to 1,000 persons living.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 9·22 | 0·09 | 0·33 | 0·06 | 0·45 | 0·26 | 0·99 | 0 | — | 3·00 |

Density of the Population.

| Area in Acres. | Population, 1871. | Population to each Acre. | Population in 1881. | Population to each Acre. |
|---|---|---|---|---|
| 6,556 | 2,879 | 0·44 | 3,411 | 0·52 |

11,816. Will you tell us why that has been taken separately?—The figures with regard to Dagenham were taken separately for this reason; two parts of the Romford sub-district were taken, namely, Barking Town and Hornchurch, which both belong to the registration sub-district of Romford. The part in which Romford itself is, I did not take, because it is a large town and away from the river. When I had done that, I found that part of that division of Romford which includes the town of Romford, comes down to the Thames and includes a considerable part of the Thames side; that part is called Dagenham; and it was impossible to get the figures of Dagenham separately from Romford from the Registrar-General's Returns; but I have got those figures by going to the original returns of the local places.

11,817. You mean you went to the tables which are sent in originally from the local places to the Registrar-General, and from which his tables are made up?—Yes. Now I have Tables Nos. 12 and 13.

*Prof. W. H. Corfield, M.D.*

13 March 1883.

## TABLE XII.

9 N. Rochford. 193.

Divisions.—Rayleigh and Prittlewell.

Including the Parishes of Rawreth, Hockley, South Fambridge, Eastwood, Rayleigh, Thundersley, South Benfleet, Hadleigh, Leigh, Prittlewell, Southchurch. Population 1871, 11,673; 1881, 15,199.

Average annual Number of Births and Deaths, and Rates per 1,000 Persons living, for Ten Years, 1871–80.

| Births. | Birth-rate. | Deaths. | Death-rate. | Deaths under 1. | Deaths at 60 and upwards. | Smallpox. | Measles. | Scarlet Fever. | Diphtheria. | Whooping Cough. | Fever. | Diarrhœa. | Cholera. | Zymotic Total. | Zymotic Death-rate. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 422 | — | 221 | — | 60 | 64 | 1 | 3 | 3 | 2 | 5 | 5 | 13 | 0 | 32 | — |
| — | 32·38 | — | 16·52 | — | — | 0·07 | 0·22 | 0·22 | 0·15 | 0·37 | 0·37 | 0·96 | 0 | — | 2·36 |

Density of the Population.

| Area in Statute Acres. | Population in 1871. | Population to each Acre. | Population in 1881. | Population to each Acre. |
|---|---|---|---|---|
| 41,089 | 11,673 | 0·28 | 15,199 | 0·37 |

## TABLE XIII.

9 S. Sheppey. 61.

Divisions.—Minster, Eastchurch.

Including the Parishes of Queenborough, Minster, Elmley, Eastchurch, Warden, Leysdown, Harty. Population 1871, 18,515; 1881, 18,185.

Average annual Number of Births and Deaths, and Rates per 1,000 Persons living, for Ten Years, 1871–80.

| Births. | Birth-rate. | Deaths. | Death-rate. | Deaths under 1. | Deaths at 60 and upwards. | Smallpox. | Measles. | Scarlet Fever. | Diphtheria. | Whooping Cough. | Fever. | Diarrhœa. | Cholera. | Zymotic Total. | Zymotic Death-rate. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 607 | — | 284 | — | 66 | 65 | 0·9 | 3·7 | 3·8 | 0·9 | 7·9 | 5·0 | 12·1 | 0·7 | 35 | — |
| — | 33·07 | — | 15·52 | — | — | 0·05 | 0·20 | 0·21 | 0·05 | 0·43 | 0·27 | 0·66 | 0·03 | — | 1·90 |

Density of the Population.

| Area in Statute Acres. | Population in 1871. | Population to each Acre. | Population in 1881. | Population to each Acre. |
|---|---|---|---|---|
| 22,453 | 18,515 | 0·82 | 18,185 | 0·81 |

10 S. Blean. 58.

*Prof. W. H. Corfield, M.D.*

13 March 1883.

Divisions.—Herne and Whitstable.

Including the Parishes of Chislett, Reculver, Herne, Swalescliff, Whitstable, Seasalter.
Population 1871, 11,783; 1881, 12,101.

Average annual Number of Births and Deaths, and Rates per 1,000 Persons living, for Ten Years, 1871–80.

| Births. | Birth-rate. | Deaths. | Death-rate. | Deaths under 1. | Deaths at 60 and upwards. | Smallpox. | Measles. | Scarlet Fever. | Diphtheria. | Whooping Cough. | Fever. | Diarrhœa. | Cholera. | Zymotic Total. | Zymotic Death-rate. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 408 | — | 212 | — | 51 | 70 | 0·6 | 1·4 | 2·0 | 2·5 | 5·6 | 4·7 | 7·1 | 0·1 | 24 | — |
| — | 34·18 | — | 17·75 | — | — | 0·05 | 0·12 | 0·17 | 0·20 | 0·46 | 0·39 | 0·59 | 0·01 | — | 1·99 |

Density of the Population.

| Area in Statute Acres. | Population in 1871. | Population to each Acre. | Population in 1881. | Population to each Acre. |
|---|---|---|---|---|
| 22,430 | 11,783 | 0·52 | 12,101 | 0·54 |

11,818. What do they show?—Table 12 contains similar statistics as far as zymotic diseases are concerned, and the density of the population, for another division upon the north side, namely, Rochford, still further down the river.

11,819. Rochford includes Southend, does it not?—Rochford includes two large towns, namely, Southend and Rayleigh. Table No. 13 gives similar numbers for two districts upon the south side further down the river.

11,820. So that with those tables you have prepared you have a complete series of statistics from London to Southend, upon either side of the river?—Yes, it is farther than Southend; it is in two parts, one to the Medway and opposite to it, or thereabouts, and another which has been done afterwards for the lower portion of the river. I shall have printed copies of the tables ready by to-morrow.

11,821. Tables 1 to 6 show the annual number of deaths from zymotic diseases during the 10 years from 1871 to 1880; is that so?—Tables 1 to 4 show the absolute numbers.

11,822. And from those numbers in Tables Nos. 5 and 6, you have calculated the average?—The average annual numbers in the 10 years.

11,823. From Tables 7 and 9, what appears with regard to the north side of the Thames?—Table 7 shows that the average zymotic death rate upon the north side of the Thames in six of those districts, is either above what it is in London, or very nearly approaches the zymotic death-rate in London.

11,824. In the first four districts the death-rate is either higher than the London death-rate, or closely approaches to it?—In the first four districts upon the north side it is all higher than the death-rate in London, and in the last four districts it is decidedly higher than the death-rate in the eastern registration division, with one exception.

11,825. The eastern registration division being that of which they form a part?—Yes.

11,826. What is the exception to which you allude?—Hornchurch. There the zymotic death-rate is almost exactly the same as it is in the eastern registration district; but Hornchurch contains no town; it consists mostly of scattered villages at a distance from the river.

11,827. That is the only instance in which the death-rate goes down?—That is the only instance where the death-rate from zymotic diseases is as low, or nearly as low, as it is in the eastern registration division.

11,828. That is to say, it is more of the character of the eastern registration division and less of a riparian character?—I should go further than that, because in the eastern division there are a good many large towns, while there are no large towns in Hornchurch.

11,829. Therefore you find that health is affected by contiguity to the river all the way down upon the north side?—The fact is, that the zymotic death-rate all the way down upon the north side is higher, as I said, than it is in the eastern registration division.

11,830. (*Mr. Michael.*) What is the death-rate from zymotic diseases?—There is a figure for each place.

11,831. (*Mr. Balfour Browne.*) The table will be handed in to-morrow when the rest of the tables are handed in, but if my learned friend wants any particular figure he can have it?—Tables 7 and 8 have been already printed, and those are very important.

11,832. Taking the deaths from the several zymotic diseases in the districts upon the north side of the Thames, does it appear from the table you have before you that those deaths from measles, scarlet fever, and diarrhœa, are in almost all instances very largely in excess of those in the eastern registration division?—Yes, those deaths from measles, scarlet fever, and diarrhœa, are all very much in excess.

11,833. Would you give the figures of the deaths from measles in the eastern registration division?—The deaths from measles in the eastern registration division are 0·17 per 1,000 persons living. Now, in Aldgate the proportion is 0·46; St. Paul, 0·73; Stepney, 0·74; Poplar, 0·68; West Ham, 0·40; Barking Town, 0·26. In Hornchurch, which is the district I have been describing as chiefly consisting of small villages, there the death rate from measles is 0·24, and in Orsett it is 0·29.

11,834. (*Chairman.*) Barking Town is the most healthy place going apparently?—It depends upon which disease you take; the death rate is less in measles than in other places, but if you take scarlet fever you find a very different result. In scarlet fever the eastern registration division is 0·40; London generally is 0·60; Aldgate is 0·66; St. Paul, 0·58;

*Prof. W. H. Corfield, M.D.*

13 March 1883.

Stepney, 0·82; Poplar, 0·85; West Ham, 0·75; Barking Town, 0·90; Hornchurch, 0·33; Orsett, 0·55.

11,835. (*Prof. Williamson.*) Do the riparian districts average more than London?—Yes.

(*Mr. Michael.*) The two distinguishing points in zymotic diseases, namely, fever and diarrhœa, are lower at Barking than any other places upon the table.

11,836. (*Mr. Balfour Browne.*) Take diarrhœa, the next column but three, and give the figures?—The eastern registration division gives 0·72 and London 0·92. Of these districts Aldgate is 1·27; St. Paul, 1·12; Stepney, 1·22; Poplar, 1·06; West Ham, 1·02, as against 0·72 for the eastern registration division.

11,837. Which is the next column you will take?—Fever.

11,838. What does fever include?—Fever includes enteric fever, typhus, and simple continued fever; but it is chiefly enteric fever, of course.

11,839. What results do they give?—In fever the eastern registration division gives 0·35. I did not mention fever, you will remember, as being excessively prevalent in those districts. Aldgate is 0·40; St. Paul, 0·37; Stepney, 0·35; Poplar, 0·37; West Ham, 0·30; Barking Town, 0·29; Hornchurch, 0·32; Orsett, the highest of the lot, gives 0·56, and London, 0·37.

11,840. As far as fever is concerned, following the figures you have just given, it seems to me that the districts and the registration division are very much upon a par?—Yes.

11,841. But in relation to diarrhœa, scarlet fever, and measles, the riparian parts of the parish are very much in excess?—Yes, and that is especially true of scarlet fever.

11,842. Is there anything in the nature of the population living along the banks of the river that would account for it to your mind?—I do not know of anything specially to account for it.

11,843. (*Chairman.*) What do you attribute it to?—I cannot tell you all the causes of it. I have very little doubt that one of the causes is the condition of the river, that is to say, one cause of the increased general zymotic death rate along its banks upon both sides, and of the special increase in certain zymotic diseases, most notably scarlet fever.

11,844. (*Prof. Williamson.*) You first said it was owing to the condition of the river. Now we want to know what there is in the sewage which causes the river to act in a different way from what it would without the sewage. This river, no doubt, produces fogs, and that may conduce to the enjoyment of a different state of health, but is there anything inherent in the condition of the river itself which leads to a different condition of health being enjoyed by those living on its banks?—I have no doubt the foul condition of the river has an effect upon the population living upon the banks.

11,845. Do those statistics lead you to say that the river with the sewage is anything worse than a river without the sewage?—It leads me to the conclusion that the high zymotic death rate is partly due to the sewage flowing down the river.

11,846. (*Mr. Balfour Browne.*) Is it your opinion then that if it were nothing but pure water flowing down the stream the death rate would be lessened?—I have no doubt that it would be lessened.

11,847. (*Dr. Stevenson.*) Have you compared the influence of living here with the influence of living upon the river higher up?—No, have not. I have compared it with the effect of living lower down.

11,848. (*Mr. Balfour Browne.*) Your tables will show that. You have dealt hitherto with the northern side of the Thames. Now, will you go to the south. Do you find the same result there—that the general zymotic death rate is increased by proximity to the river?—Yes, it is higher in all the districts upon the south than it is in the general south-eastern division.

11,849. (*Sir John Coode.*) How does the district east of the Medway compare with that to the west of it?—Upon the north side east of the Medway the zymotic death rate is a little below the death rate of the eastern registration division. The north side includes the two large towns of Southend and Rayleigh, and the death rate is rather less than in the whole eastern registration division. Upon the south side the zymotic death rate of Sheppey is decidedly less, and the zymotic death rate of Blean, which is a little further on, is a little less than that of the south-eastern registration division generally.

11,850. Is not that to be expected as we are getting on to the sea-board where you get more of the pure sea breezes?—No doubt.

11,851. (*Mr. Balfour Browne.*) As a fact, you find that in the Isle of Sheppey the death-rate is lower than in the whole of the south-eastern registration division?—Yes, it is.

11,852. (*Sir John Coode.*) And there you get on to the chalk, which is also healthier?—It is undoubtedly healthier there.

11,853. (*Mr. Balfour Browne.*) Now, taking the south side in the same way as you did the northern side, would you trace what is the indication down that bank, of measles, scarlet fever, and diarrhœa?—In measles the death rate of those districts is higher than that of the south-eastern registration division, with the exception of Gravesend, where it is a little lower.

11,854. Otherwise is it much higher?—It is decidedly higher.

11,855. Can you do the same there as you did upon the north?—I can say that on the south, in respect to these three diseases, the death rate in each of these districts I have taken is higher: there may be one exception, namely, Gravesend, in the case of measles, otherwise the death-rate is almost in every instance higher than the corresponding death rate for the south-eastern registration division. As regards fever, however, I must except Hoo, for this reason, that the people there seem to die of nothing but fever; everything seems to be put down to fever in Hoo. There is scarcely any scarlet fever, and scarcely any measles there, but the death-rate from "fever" is enormous; so that it is perfectly clear that they put down everything that is of a feverish nature as "fever." When you look at the table you will see that the sub-district of Hoo has a death rate from "fever" not far off three times that of London.

11,856. But that is to be accounted for by the fact that they have no death rate in anything else?—I would say that that district must not be considered except as regards the general zymotic death rate.

11,857. Now, leaving that out, does it prove that deaths from zymotic diseases in the riparian parts of this district on the south side are very much greater than in the south-eastern registration district?—Yes, it does.

11,858. Upon the north side does the mortality exceed that in London generally?—I have only the zymotic diseases in these tables.

11,859. Taking them altogether, does the rate of mortality from all diseases north of the Thames exceed the average for London?—It does from zymotic diseases.

11,860. Upon the south side is the same the case, is there an excess of the zymotic death rate there over the whole of London?—Not over the whole of London, with the exception of St. Olave's, Southwark.

11,861. In the other cases the zymotic death rate exceeds that of the districts of which they form a part?—Yes. There is one sub-district, that of Bexley, where, I believe, the actual majority of the population is in places at a considerable distance from the river, and while the zymotic death rate there is about equal to the death rate of the south-eastern division, generally, the death rate from scarlet fever is very much higher than it is in that division, and very nearly approaches that of London.

11,862. Now what does Table 9 show?—Table 9 shows the density of the population in each of those

districts on each side of the Thames in 1871 and in 1881; it shows the area in acres in each district or sub-district; the population in 1871 and in 1881, and the population per acre in 1871 and in 1881, and then it shows the corresponding figures for London and for the eastern registration division.

11,863. Upon Table 9 have you the density of the population in Orsett?—Yes.

11,864 Is the density of population there the same as that of the eastern division generally?—It is almost exactly the same; it is slightly less.

11,865. Can you tell the Commission whether the death rate from zymotic diseases is about the same?—It is decidedly greater than in the eastern registration division.

11,866. Now by Table 10 you give the density of the population upon the south side?—Yes.

11,867. Would you look at the district of Northfleet?—Yes, I will.

11,868. Is the density of population in the district of Northfleet the same as for the south-eastern registration division?—Yes, almost exactly. *Prof. W. H. Corfield, M.D.*

11,869. Is the death rate from zymotic diseases, such as scarlet fever and fever, higher in Northfleet than in the south-eastern registration division?—Yes, it is, very considerably, in Northfleet it is higher than in any other place below Greenwich. 13 March 1883.

11,870. Northfleet is just above Gravesend is it not?—Yes, Northfleet is just above Gravesend.

11,871. There might be accidental irregularities upon these tables, how have you eliminated those?—By taking the statistics separately for 10 years for each year and averaging them.

11,872. You think that is sufficient to eliminate any possible irregularities that might vitiate the smaller induction?—Yes.

(*Mr. Lumley Smith.*) As I understand, my learned friend wishes to have the person produced who took the samples for determining the amount of chlorine at Southend.

(*Mr. Michael.*) At Gravesend and Southend.

Adjourned to to-morrow at 12.30.

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# THIRTIETH DAY.

## Wednesday, 14th March 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR P. BENSON MAXWELL.
SIR JOHN COODE, Mem. Inst. C.E.
PROFESSOR WILLIAMSON, F.R.S.

FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst. C.E.

WILLIAM POLE, Esq., F.R.S., *Secretary.*

Professor W. H. CORFIELD called again and further examined.

11,873. (*Mr. Balfour Browne.*) Have you the tables which you promised to hand in to the Commission yesterday?—I have. (*See Evidence of previous day.*) 14 March 1883.

11,874. I think when we left off you were going to give a description of Table 11; will you now proceed to do so?—Table 11 refers to a place called Dagenham, which is part of the division of Romford, which is itself part of the sub-district of Romford. This is given in a separate table, because I was not able to get it from the Registrar General's returns direct, but had to go to the returns sent in by the local registrars. I have taken out from them the death-rates, and the number of deaths during the 11 years from 1871 to 1881, from each zymotic disease, and the total number, and from them I have calculated the average annual number for the 10 years from 1871 to 1880, and the average annual death-rate for the 10 years from 1871 to 1880, as I did with regard to the previous districts. I find that the zymotic death-rate in that small district is 3 per 1,000 per annum, as against 2·38 in the eastern registration division generally, of which this forms a part.

11,875. The situation of Dagenham is just below Barking Creek, is it not?—It is a little way below Barking Creek; it is part of the district that is included in Romford.

11,876. (*Chairman.*) Is the general death-rate greater there than in the other place you have compared it with?—I am afraid I have not the general death-rate for Dagenham.

11,877. (*Mr. Balfour Browne.*) The witness is only taking the death-rate from zymotic diseases; he is comparing the death-rate from zymotic diseases in districts down the river with the death-rate in the districts away from the river; is that so?—Yes, the general death-rate is to be found in Tables 1 and 2, but I cannot answer as to the general death-rate with regard to Dagenham. I should like to add that, with regard to the district of Dagenham, I was not able to get the deaths from the Registrar General's returns, else I should no doubt have given that, but I had to go to the original returns sent in by the registrar of the place to get them, and I have only worked out the deaths from zymotic diseases, which is what I was inquiring into.

11,878. Have you made a comparison with the districts immediately below those included in the tables you have put in?—Yes.

11,879. Those are on the north side, part of the Rochford sub-district.

11,880. (*Chairman.*) Are the conditions of the districts compared the same, or are the districts that you have compared the river-side districts with upon a hill or what not?—The comparison is this: there are certain districts upon the north bank of the Thames between London Bridge and opposite the Medway. These sub-districts form part of the eastern registration division, which includes the counties of Essex, Suffolk, and Norfolk. I have compared the zymotic death-rates in the districts bordering upon the north side of the Thames with the zymotic death-rates of the general districts of the eastern registration division of which they form a part.

11,881. You are comparing, as I understand, the zymotic disease-rate in low lands, with the zymotic disease-rate in lands that are both high and low?—Yes, that is necessarily so.

11,882. That seems to me to take away a great part of the value of it, unless you can say that the

*Prof. W. H. Corfield.*

14 March 1883.

populations on the low lands have no greater tendency to zymotic diseases than those upon the high lands?—Then I go on to compare the death-rate in the districts near the Thames with those in the districts lower down the Thames.

11,883. (*Mr. Balfour Browne.*) You have compared, have you not, the death-rates of the places higher up the Thames with the death-rate of the districts of Rochford on the north side, and the island of Sheppey and Blean on the south side?—Yes.

(*Mr. Bidder.*) Those are salt water districts.

(*Witness.*) Table 12 shows the annual number of deaths from zymotic diseases, and the annual death-rate in the districts of Rochford, Table 13 and those for Sheppey, and Blean.

11,884. (*Mr. Balfour Browne.*) Where is the sub-district of Rochford?—It is upon the north side of the Thames, and includes the places of Southend, Rayleigh, and Prittlewell.

11,885. What places do you take on the south?—Sheppey and Blean.

11,886. What does the table show with regard to zymotic diseases in Rochford?—Table 12 shows that the average death-rate from zymotic diseases in Rochford for the 10 years is, practically speaking, the same as that for the eastern registration district generally.

11,887. Which includes the three counties you have mentioned?—Yes, it includes the three counties which I have mentioned, with their towns.

11,888. Therefore in Rochford the death-rate from those diseases is lower than in the riparian sub-districts higher up the river?—Yes, it is.

11,889. (*Chairman.*) Rochford is in a very low situation, is it not?—Yes. Then I should add that in that district of Rochford the scarlet fever death-rate is less than in the eastern registration division, and very much less than in any of the districts up the Thames.

11,890. (*Mr. Balfour Browne.*) Scarlet fever is a disease to which you have specially drawn attention in these tables?—Yes, it is the disease which is shown to be specially prevalent in those districts near to the banks of the Thames above the Medway.

11,891. (*Chairman.*) Some part of the eastern registration division is the most healthy district in England. I should think the chalk lands of Norfolk are very dry though not very high; and there is no part of England more healthy, is there?—I have no doubt that they are very healthy, but I have not gone into the case of those parts.

11,892. (*Mr. Balfour Browne.*) In the eastern registration division there are a very considerable number of large towns, are there not?—Yes.

11,893. Of course the condition of those has a good deal to do with the spread of zymotic diseases?—No doubt.

(*Chairman.*) What struck me about Rochford being so healthy was that it appeared to prove too much.

11,894. (*Mr. Balfour Browne.*) These healthy places that you have been referring to in the eastern district bring down the death-rate as against the large towns?—They do.

(*Mr. Bidder.*) The death-rate in the eastern district is very low.

11,895. (*Dr. Stevenson.*) I would ask you whether the defective registration of which you spoke would have anything to do with the result shown by these figures, that is to say, the registration of a case of scarlet fever as a simple case of fever; have you been able to trace that practice in any other place?—I have not noticed that to any extent. Of course there is the possibility that in Rochford some cases of scarlet fever may be registered as measles. If you take scarlet fever and measles together you get in the eastern registration division generally ·57, and if you take Rochford you get ·44.

11,896. (*Chairman.*) Have you any comparison between your other places and such a place as Grays or Purfleet, where it is not marsh land, but chalk at some elevation?—Grays and Purfleet come into some of those divisions which I have got, but I have not been able to take them separately.

11,897. (*Mr. Balfour Browne.*) Of course Grays and Purfleet are in some of your divisions; will you just find out what division they are in, and give the death-rate?—Grays comes in under Orsett, and the zymotic death-rate of Orsett, taking it altogether, is certainly higher than it is in the eastern registration division.

11,898. (*Chairman.*) You are giving the district in which Grays is?—Yes; I am not able to give Grays separately.

11,899. (*Chairman.*) How is Sheppey divided?—Sheppey is divided into Minster and Eastchurch.

11,900. Minster is pretty high ground, is it not?—Yes, but I have not been able to separate the figures.

11,901. (*Mr. Balfour Browne.*) I want you to do the same upon the south side of the river as you have done upon the north, that is to say, compare the river-side places with that which is at the mouth of the river, namely, Sheppey and Blean?—The zymotic death-rate in Sheppey during the 10 years has averaged 1·9 as against 2·38 in the south-eastern registration district generally; that is to say, the zymotic death-rate of Sheppey is less than in the south-eastern registration division generally.

(*Chairman.*) Has it ever been suggested that the influence of the sewage has been felt in Sheppey?

(*Mr. Balfour Browne.*) No; the witness would say that the influence of the sewage has died out before reaching Sheppey, and that, therefore, the death-rate has gone down.

(*Chairman.*) Then, in fact, you might take Newcastle-upon-Tyne or any other place to compare with.

(*Witness.*) I show that the death-rate in Sheppey is less than in the south-eastern district generally.

11,902. (*Mr. Balfour Browne.*) And the same, of course, with regard to Blean?—Yes, the same with regard to Blean.

11,903. Would you compare those two with regard to the death-rate in scarlet fever?—In scarlet fever they are both less than in the south-eastern registration division generally, and decidedly less than in any of the districts upon the south side of the Thames, which I have already spoken of, with the exception of Hoo, which I mentioned yesterday.

11,904. (*Chairman.*) Where is Blean?—It is a district beyond Sheppey; it includes Herne and Whitstable.

11,905. (*Mr. Balfour Browne.*) With regard to scarlet fever, you say that until you come down to Sheppey and Blean the death-rate from scarlet fever is higher than in the division of which those places form a part?—Yes.

11,906. With the exception of Hoo, where they register everything as fever?—Yes.

11,907. Something was said yesterday about the character of the soil of Sheppey and Blean. I think Sir John Coode suggested that it was chalk, and that, therefore, that might account for the health of those districts?

(*Mr. Abernethy.*) The soil of Sheppey is not chalk.

(*Chairman.*) A part of Sheppey is comparatively high land, with cliffs to the sea, in which pyrites are found.

(*Mr. Balfour Browne.*) It was suggested yesterday that chalk was the soil; what do you say is the soil?

(*Witness.*) It is practically all tertiary clays or post-tertiary alluvial deposits in all those districts; you do not get to the chalk, in fact, until you come to Canterbury.

11,908. I think, roughly, in all these tables you lay special stress upon scarlet fever as an indication of the health upon the banks of the Thames?—Yes, that is what the tables show especially.

11,909. Is there anything that you wish to add in explanation of any of those tables?—I do not think so.

Cross-examined by Mr. BIDDER.

*Prof. W. H. Corfield.*

14 March 1883.

11,910. I suppose there is no doubt about the truth of one statement or the accuracy of one observation you referred to this morning, that density of population has a great deal to do with the deaths from zymotic diseases?—Yes, no doubt it has.

11,911. Apart from any other element?—No doubt it has.

11,912. Consequently, taking any district in London, you expect to find a higher death-rate from zymotic disease than if you take districts in the country?—No doubt you would expect to find that the case.

11,913. (*Sir P. Benson Maxwell.*) But when you say you expect to find it, have you any experience that you do find it; is it the result of observation?—I can, no doubt, pick out a part of London where the zymotic death rate is less than in several of those districts where the density of population is less than in London.

11,914. Taking two districts of different density of population, would you expect to find more zymotic disease in the more densely populated district?—You would.

11,915. Is that the result of your experience and observation, or is it a theory of your own?—It is the result of experience, but still it is dependent upon circumstances. I can give you a number of cases of less zymotic disease with a denser population.

11,916. (*Chairman.*) Is that a recognised principle in medical science?—Yes.

11,917. (*Mr. Bidder.*) Experience, not only in London but throughout England shows, does it not, that as the density of population increases so, *cæteris paribus*, the death-rate from zymotic diseases rises?—Yes, but I can give you exceptions.

11,918. Now I will put to you another general proposition, and I will ask you whether this is not applicable to London and other towns where the population is more or less dense, that in the parts of the towns where the poorer classes are more or less collected together you find the zymotic death-rate higher than in the parts of the towns where the better and higher classes principally reside?—That is so, no doubt.

11,919. Applying that to London, that would be saying, in other words, that the East London zymotic death-rate is higher than the West London zymotic death-rate?—It is higher as a rule.

11,920. Quite apart from density of population?—Quite apart from density of population.

11,921. So that the average zymotic death-rate of the whole of London being, as you give it in Table 7, 3·84, without any reference to any influence of the Thames, you naturally expect the zymotic death-rate of East London to be something above 3·84, and that of West London to be below it?—Supposing the population of Eastern London to be the denser.

11,922. Not supposing anything; taking Eastern London as it is?—Assuming the population in Eastern London is denser, I should expect it.

11,923. Do not assume anything. As a matter of fact, the population is denser in Eastern than in Western London?—That is so.

11,924. Besides its being denser, as a matter of fact, it is a much poorer population in Eastern than in Western London?—No doubt it is.

11,925. Those two causes both operate to raise the death-rate from zymotic diseases in Eastern London above the average?—Yes.

11,926. That applies to all Eastern London, whether riverine or not?—Yes, it does, no doubt.

11,927. (*Sir P. Benson Maxwell.*) Do you know anything about the comparative density of the eastern population of London and the western population of London?—I cannot give you the figures; I can only speak as it in general terms.

11,928. (*Mr. Bidder.*) You have given in your Table 9 the density of population per acre?—That is in Tables 9 and 10.

11,929. The one for the population on the north and the other for the south side of London, but, unfortunately, you only give it for the districts you have selected, which are all districts of East London. Can you, by reference to the Registrar General's returns, give the figures for Western London?—At any rate, the figures given in my table show that the density of population in the first four districts upon the north side of the Thames is greater than it is in London generally, and considerably greater than in some of the others.

I am much obliged to you. You show that several of these districts, the first four, are far above the London average.

(*Chairman.*) I might tell you that Mr. Heywood has been kind enough to tell us, that he, on a former occasion, calculated the density of population, and found it was greatest in the sub-district of St. Anne's, Soho, and one of the Holborn sub-districts. I think that likely, because the houses are larger there, and, if it is a poor population, the streets being narrow, you have more people living upon the same piece of ground.

11,930–31. (*Mr. Bidder.*) That would be so; but, dealing with the particular districts dealt with by the witness by Table 9, Dr. Corfield shows that upon the north side of the river the four first districts have a population denser considerably than the average of London. London is given at the bottom of the table as 50 to the acre. (*To the witness.*) Now, if you turn back to Table 7, those are the very four districts in which you show a zymotic death-rate above the average zymotic death-rate of London?—Yes, it is above the average of London.

11,932. Of the other districts you have selected, West Ham, Barking, Hornchurch, and Orsett, the last two are mere country places; but, taking Barking and West Ham, they have a density below, and considerably below the average of London, and when we turn back to Table 7, we find that the zymotic death-rate is slightly below the average of the zymotic death-rate of London?—That is so.

11,933. Now, will you take the south side of the river, Table No. 10?—I was going to say that, if you keep to London, the zymotic death-rate of Barking and West Ham is very little below the death-rate of London, whereas their density is enormously less.

11,934. But you do not suggest that even when you get into the pure country you eliminate zymotic disease; your own tables show that you have it in the most healthy districts. Now, Table 10 gives us the same things for the south side, and that shows that only one district you have selected, namely, St. Olave's, Southwark, is above the average density of London as regards population?—Yes.

11,935. Then, turning to Table 8, that is the only district whose zymotic death-rate is above the average for London?—It is above the average for London; but the fair thing to compare these with is not the death-rate of London, but the death-rate of the registration divisions to which they belong.

11,936. Take St. Olave's, Southwark; what do you say it would be fair to compare that with?—It would be fair to compare that with London.

11,937. Take Greenwich?—The population of Greenwich is 38·3 to the acre; it is fair to compare that either with London or with the general registration district.

11,938. Is that the registration division which is at the foot of that table?—That is the registration division.

11,939. The population of which, instead of being 38 people to the acre, as in Greenwich, is half a person to the acre; would that be fair?—The population in Greenwich is only two-thirds of the proportion in London; in London it is 50·6.

11,940. Surely you know that the population of Greenwich is essentially an urban population?—Yes, it is.

11,941. What brings down Greenwich really to

*Prof. W. H. Corfield.*

14 March 1883.

below the average of London is the fact that Greenwich Park is within it, and helps the acreage, is it not?—Yes.

11,942. And nobody but the Astronomer Royal and his assistants lives in Greenwich Park?—That is so.

11,943. There is also Blackheath in it?—Yes, there is.

11,944. Now, Tables 12 and 13 refer, for places of comparison, to Rochford, including Rayleigh and Prittlewell; to Sheppey, including Minster and Eastchurch; and to Blean, including Herne and Whitstable; are not those essentially seaside places?—They are estuarian; they are in the estuary, no doubt.

11,945. Herne Bay is a place to which people go for bathing, is it not?—It is.

11,946. And Whitstable is a place sufficiently marine for oysters, at all events?—Yes, it is so.

11,947. And, as the tables show us, the density of the population is remarkably thin. Blean has only half a person to the acre, Rayleigh and Prittlewell only one third, and Minster and Eastchurch ·8 of a person?—That is so, but they are about a fair average of the registration division generally, so it is fair to compare their death-rates together.

11,948. Now, turning back to Tables 7 and 8, the selected districts, is it not the case that many of those districts which you have selected, although they are riverine in the sense that in one part of their boundary they touch the river, run very far back from the river, and a very small proportion of their population is contiguous to the river?—Not a very small proportion. There are, it is true, some of those districts in which most of the population is away from the river; but, in most of those that I have selected, the population is near the river, at any rate.

11,949. Have you any map which will show the boundaries of the districts?—I have a map upon which the districts have been roughly marked. (*The same was handed to the learned counsel.*)

11,950. Which of your districts does Limehouse fall within?—Stepney.

11,951. Have you taken the City of London?—No.

11,952. That is a riverine district, is it not?—I begin at London Bridge. Aldgate is the first below London Bridge, Aldgate being part of Whitechapel.

11,953. I see Stepney runs back a mile or more from the river, does it not?—I dare say it does run back a mile or more from the river.

11,954. How far do you suggest that the influence of the River Thames, if it has a deleterious influence, could possibly be conceived to extend?—I cannot tell. I am told that sewage can be smelt three miles from the river. I have never smelt it three miles from the river.

11,955. Do you believe it?—I do not know whether to believe it or not.

(*Chairman.*) Barking Town is more than a mile from the river, is it not?

(*Mr. Bidder.*) It is about two miles from the river.

(*Chairman.*) You see the death-rate from zymotic diseases in Barking Town is 3·12.

(*Mr. Bidder.*) As against 3·84 for London generally.

(*Witness.*) And as against 2·38 for the eastern registration division.

(*Sir P. Benson Maxwell.*) Barking Town is full of cesspits, I believe, and that might account for that proportion of zymotic disease.

(*Witness.*) I ought to say that Barking Town means the district; it does not merely mean the town; it means the district which comes down to the river.

11,956. (*Mr. Bidder.*) I will go regularly along. I have asked you about Stepney. Now, the Poplar district goes back as much as three miles from the river, that is to say, what you have embraced as the Poplar district?—I can only tell by referring; but when you say "what I have embraced," I have only embraced what I was bound to do by the returns of the Registrar-General. The farthest point of Poplar to the nearest point of the river is about 2½ miles; if you take it from the farthest point of Poplar to the farthest point of the river you may make four miles of it.

11,957. How far does West Ham stretch back from the river, taking the farthest part of it?—The farthest point of West Ham from the river is three miles.

11,958. Now with regard to Barking Town district, how far does that go back from the river?—2½ miles at the outside; it is hardly as much as that.

11,959. By-the-bye, passing back for a moment to the West Ham district, if I remember rightly, the population there lies away from the river, and the immediate banks of the river have a comparatively sparse population, because it is occupied principally by docks, and open land opposite Woolwich?—That is so, the population is mostly away from the river.

11,960. Now I go to the next, the Barking district embraces the actual outfall itself, does it not?—That is not marked upon my map.

11,961. Is it not the case that your Barking district actually embraces the northern outfall?—No, I think not. I think the northern outfall is in the West Ham district, but it is not marked upon my map.

11,962. You are quite right, the outfall is just at the boundary, between Barking and West Ham, and above the Barking district. Now, I suppose, if the sewage has any deleterious effect upon health, you would expect that it would be strongest in the immediate neighbourhood of the sewage outfalls?—I do not know that, but if the whole state of the river is in a bad condition—

11,963. If it is bad, it would be worse near the outfalls?—At times it would be worse near the outfalls, no doubt.

11,964. I see your returns show Barking to have, as compared with the other places, a remarkably low average of zymotic disease?—You will see also that it has an enormously high death-rate from scarlet fever, higher than the east of London, and the other places.

11,965. Of course that includes Barking Town; are you aware of the condition of Barking Town itself, as to its sewage?—I know something about it.

11,966. Do you know that Mr. Rawlinson held an inquiry under the Local Government Board, and made a report upon the case some years ago, in 1869, it was called an inquiry as to the truth, or otherwise, of certain allegations which were contained in a memorial from the vicar, and other inhabitants of Barking, in the county of Essex, calling attention to the pollution of the River Thames, by the discharge from the northern outfall sewer of the Metropolitan Board of Works, now just let me draw your attention to one sentence.

(*Chairman.*) Perhaps Mr. Bidder would ask whether that did not differentiate the case of Barking, so that you cannot take it as a criterion.

(*Mr. Bidder.*) Mr. Rawlinson says as one of the "conclusions" of his report, "that the memorialists "are not in a position to establish deterioration of "health to emanations from the metropolitan main "sewerage outfall works, as the town of Barking is "without local governing powers, is unsewered, "contains many cesspools, a sewage tainted subsoil, "and has a defective water supply."

11,966*a*. (*Sir P. Benson Maxwell.*) Do you know whether that is true or not?—I do not know.

11,967. (*Chairman.*) I think we may take it for granted that we do know, this being so authoritative a statement that I think the Commission would act upon it. Then I suppose the question is, supposing that to be true, does not that preclude Barking from being used as a criterion, one way or the other?—To a certain extent it does, but what I show is that the death-rate from zymotic diseases, especially from scarlet fever, is excessively high along both banks of the Thames.

11,968. Mr. Bidder will get rid of it, no doubt, bit by bit, as soon as he can, but that, I think, he will contend will get rid of Barking?—Except that the

learned counsel was not here yesterday, when I introduced this subject.

(*Mr. Balfour-Browne.*) Only it must be remembered that that paper refered to 1869, and the tables refer to the period from 1870 to 1880.

11,969. (*Mr. Bidder to the witness.*) Now I will ask you a question about the corresponding Table 8, which relates to the south side; do you include Bermondsey, and if so, in which of your divisions do you include Bermondsey?—St. James', Bermondsey, that is to say, part of Bermondsey, is included.

11,970. Why did you not take the whole of Bermondsey?—I took St. Olave's Southwark, St John, Horseleydown, and St. James', Bermondsey, and Rotherhithe, they are all riparian.

11,971. (*Chairman.*) Is Deptford in either of the districts?—Yes, that is in Greenwich.

11,972. (*Mr. Bidder.*) Now your next district is Greenwich?—Yes.

11,973. Is it not the fact that in certain of these districts of the Registrar-General's, and the observation applies, I think with particular force, to Greenwich, and another that is mentioned, deaths are included which occurred at hospitals situated in those districts where patients are taken in, who contract their illness in other districts?—That is the case, no doubt, in some of the districts. I dare say it is in Greenwich, but I do not know that.

11,974. Do not you know, for instance, that in Greeenwich the death-rate from zymotic diseases is largely affected by the presence of patients in the hospital, brought from other places?

(*Chairman.*) Which hospitals do you refer to?

11,975. (*Mr. Bidder to the witness.*) To begin with, are you not aware that there was a small-pox hospital which accommodated the population of a great part of London, and which was only removed, I think, about 18 months ago, lower down the river into the sewage section, as being a healthier spot. Now are you aware that the death-rate of the floating hospital has been included in the zymotic death-rate?—I have no doubt that it has.

11,976. Have you eliminated those deaths?—No, I have not.

11,977. (*Chairman.*) Do you suggest that the influence of the sewage is sensibly felt as high as Rotherhithe, Bermondsey, and that neighbourhood?—I do not suggest, with regard to the figures at the beginning of the scale, as high up in the river as that, that the influence of the sewage has anything to do with those figures.

11,978. But in the St. Olave district the death-rate from zymotic disease is higher than anywhere else on your table?—But there the population is denser.

11,979. And you have Guy's Hospital; I do not know whether that makes a difference?—Yes, that would be in it. I began at London Bridge, for the sake of some place to begin at, but I do not suggest that I can show that the sewage has any influence as high up as that.

11,980. If the population is denser there, it would rather go to show that places lower down and more within the influence of the sewage, are better off than they are in Southwark?—So they are better off, because the population is denser in Southwark.

11,981. (*Mr. Bidder.*) I suppose your figures are taken from the returns of the Registrar-General?—They are taken from the quarterly returns, not from the annual summaries.

11,982. In Poplar also, I think there is a hospital which accommodates a very large district, is there not?—I do not know as a matter of fact that there is; I do not remember that.

11,983. (*Chairman.*) The London Hospital, in the Whitechapel Road, is not in Poplar, I suppose?—I do not know.

11,984. (*Mr. Bidder.*) Now I will read you a passage from the Registrar-General's Return for 1881. "In the southern group, which is the second highest "rate, there are two small-pox hospitals, and the "districts which would be specially affected by their "presence, would be Greenwich, Camberwell, and "Lambeth." Now here, you see, the Registrar-General himself, is of opinion, that the Greenwich death-rate is very much affected by the presence of the small-pox hospital?—It is, no doubt; my tables show that it is.

11,985. But you tell me you have not eliminated from the Greenwich death-rate, those deaths that are due to the hospital patients brought from other districts?—That is so. I have not been able to do so for any of those districts.

11,986. (*Professor Williamson.*) Are there hospitals for zymotic diseases in several parts of London?—There are in several districts.

11,987. Are they specially about the river?—They are not.

11,988. But are not patients who are or may be afflicted by zymotic diseases admitted to general hospitals?—Yes; with certain zymotic diseases, enteric fever, and diptheria, and in certain hospitals, (one or two) with scarlet fever; but cases of enteric fever and diptheria are admitted to any of the general hospitals.

11,989. Are there special hospitals to which scarlet fever patients are admitted?—There are special hospitals to which scarlet fever patients are admitted.

11,990. Where are they located?—There is the Fever Hospital at Homerton, and another at Stockwell.

11,991. (*Dr. Stevenson.*) The small-pox hospital is now at Deptford?—It is. You see the death-rates from small-pox are higher in Greenwich and Dartford in these tables, than they are anywhere else on the south side, and at Greenwich the death-rate is higher than the general death-rate in London.

11,992. (*Mr. Bidder.*) There was a small-pox hospital at Homerton, was there not?—There was, I believe.

11,993. Do you know whether it was not the fact that the patients at the small-pox floating hospital, moored at Greenwich, were found to be healthier and to do better than those in the hospital at Homerton, and at other places on land?—I do not know that.

11,994. Now I will ask you a general question; is it not the case that following shortly, or within a year or two after the completion of the main outfall drainage system and the pouring of the sewage into the river at Barking and Crossness, there was a most marked and permanent improvement in the death-rate of London?—I am not aware of that at the moment.

(*Chairman.*) But permit me to put it to you, Mr. Bidder, in this way; if you poured it out about 5 or 6 miles away, at the edge of the London population, instead of pouring it out all amongst them here, would that not account for the falling off in the zymotic disease rate, supposing that sewage had anything to do with it; it would rather tell against you than anything, I should have thought, but you have the right to ask the question in the interests of truth, no doubt.

(*Mr. Bidder.*) From my learned friend's view, yes, but from mine, no, my lord. However, I will not follow that up.

11,995. (*Sir P. Benson Maxwell.*) Do you know whether the rate of zymotic disease in the upper part of the metropolis has fallen since the sewage has been carried down below?—I believe it has.

11,996. *Mr. Bidder.*) You know, I daresay, that the Registrar-General gives the deaths from zymotic diseases per 1,000 of the population for every year for many years past?—Yes.

11,997. Will you just look at that table (*handing a copy of the Registrar-General's Return to the witness*). I think that shows, upon the face of it, that to about the year 1870 or 1871, the number of deaths ranged between 5 and 6, and from that time downwards they have ranged somewhere between 3 and 4 per 1,000; in point of fact, they are not very much more than half what they were before?—Yes; it is true that down to the year 1871 they range from 3½ upwards.

(*Chairman to Mr. Bidder.*) But need you trouble

*Prof W. H. Corfield.*

14 March 1883.

Dr. Corfield with this, because I do not understand that you are going to ask him a question upon it; you might put the book before us when you come to address us.

11,998. (*Mr. Bidder.*) I will do it in that way. (*To the witness*), I have asked you about Greenwich. Now the Woolwich district, the next you take, runs back, I think, about three miles from the river?—The farthest part is about three miles from the river.

11,999. That is the Bexley district?—But most of the population in the Woolwich district is within a mile of the river.

12,000. The Bexley district, which you have taken, runs back about five miles?—It does.

12,001. How many miles does the Dartford district go back?—The farthest point would be about five miles from the river.

12,002. Northfleet goes back about nine miles from the river, and you show that as about the highest of them all?—I have included what is in the district. I have not been able to divide the district.

12,003. How far back do you say the district goes?—The farthest point would be about 7½ miles from the river.

Re-examined by Mr. Balfour Browne.

12,004. Just let me understand; you have included in these districts, nothing but what is included in the sub-district of the Registrar-General?—No, or in parts of the sub-district which I have been able to take.

12,005. Perhaps the better plan would be to draw a line from the river to a certain distance off, where you supposed the influence of the river would terminate, and find out what the death-rate in that was?—It would, no doubt, but that would have been impracticable.

12,006. Now taking Greenwich, which is the highest one of all, I think the death-rate from zymotic diseases was lower than in the other districts, that is to say, if you deduct the smallpox?—It is on the second sheet of Table No. 2.

12,007. Deducting the 49 which represents the smallpox?—

12,008. (*Chairman.*) Hoo is certainly out of the reach or influence of the sewage, is it not?—I should think it is. Hoo is below Gravesend.

12,009. Its population is very nearly the lowest of all that you have; it is ·17 to the acre?—Yes.

12,010. I think there is no other so low as that?—I think that is the lowest.

12,011. And yet the death-rate from zymotic diseases is 2·63, that is above the average; no doubt it is not so great at St. Olaves, Southwark, nor so great as Greenwich, but greater than Bexley, and nearly as great as Dartford, and nearly as great as Gravesend?—The reason of that is the high death-rate in the sub-district from diarrhœa.

(*Mr. Bidder.*) And fever.

12,012. (*Chairman.*) What causes the diarrhœa?—Diarrhœa is chiefly caused by drinking impure water. I do not attach much importance to the death-rate in this particular case; "fever" includes everything else; if that which is put down is the death-rate from scarlet fever, then Hoo is abnormally low.

12,013. (*Mr. Bidder.*) But the death-rate from "fever" is higher than anything else?—That is because the medical attendant puts down everything he does not know as "fever," there is no other way of accounting for the death-rate from "fever" but that.

12,014. (*Mr. Balfour Browne.*) My learned friend read you an extract from the Registrar-General's Report to show that the death-rate in Greenwich, Camberwell and Lambeth, was attributable to smallpox hospitals?—Yes.

12,015. And Greenwich appears in London?—Yes.

12,016. And all the other London Districts you have given go to swell the death-rate of London?—Yes.

12,017. Now taking the districts upon the south side, the density of population is very much smaller than in London?—Which districts do you refer to?

12,018. The districts upon the south side?—All except one.

12,019. With the exception of St. Olaves, it is less than the density of London?—Yes.

12,020. And yet the zymotic death-rate is not nearly so high; in Northfleet it is higher?—No, I do not think so.

12,021. In Northfleet it is 3·43; but I was wrong in saying "the zymotic death-rate; look at the "scarlet fever" column; is it not the fact that in several of those districts it is higher than London; take Gravesend, Woolwich and Northfleet?—In those three places it is higher than in London.

12,022. Greenwich is nearly as high?—Greenwich and Dartford are both nearly as high.

12,023. In giving your opinion that the high death-rates in this column which you have particularized, "scarlet fever, measles, and diarrhœa", are due partly to the river as one of the causes, have you taken into consideration this density table which you have put in?—I have. I especially draw attention to the "scarlet fever" because, as I said, diarrhœa is caused chiefly by another means.

12,024. As I said, scarlet fever is highest in the Barking Town district which, as you have said includes a large district, besides the small town of Barking?—Yes, that is so.

12,025. In those districts is the area of the river taken into consideration in the acreage?—I am afraid I cannot tell you that.

12,026. Because if that were the case it would diminish the ratio of population?—No doubt.

Examined by the Commission.

12027. (*Dr. de Chaumont.*) In presenting these statistics to the Commission, do you merely present them as facts to be considered, or do you suggest it as your own opinion, that the sewage has an influence upon the death-rate?—I present them, in the first place, as facts to be considered, and in the second place, I give my own opinion that the emanations from the river must have some influence.

12,028. Do you think that the differences of the death-rate from scarlet fever, and so on, in the riparian districts, are due to the sewage in the river?—I believe that is one of the causes of the difference.

12,029. A material cause?—I do not know how far. I would say that——

12,030. Do you think it is the chief cause?—I should not like to go so far as to say that it is the chief cause. I do not think that I should be justified in saying that it is the chief cause. I think it is one of the principal causes operating upon the zymotic diseases upon both sides of the Thames.

12,031. Have you any means of eliminating other causes so as to appreciate the amount of causation of this river?—One way was that which the learned counsel suggested, that I should like a certain distance, say, a mile from the river, and take the death-rate within that limit; but that is obviously impracticable.

12,032. Have you had any data for eliminating other causes in forming your opinion, so as to estimate the relative amount of causation of the river and other causes?—I do not know that I can answer that. I can only point out that some of the districts which have only places near the river, give examples of very high death-rates. Dagenham, for instance, which I took out in order to avoid Romford, and which is all close to the river, has a very high zymotic death-rate, and an exceedingly high scarlet fever death-rate.

12,033. (*Professor Williamson.*) It is a low, marshy district, is it not?—A good many of them are low, marshy districts, but I do not know that that has much to do with scarlet fever.

12,034. Have you any statistics relating to the death-rate of riverine populations by rivers similar to the Thames, where sewage is not present in the river, or rather a comparison of the death-rate of such a population with that of a population lying a little farther from the river as in London?—I have not at present any such statistics; if I had had a little more time, I should have got out some.

12,035. Because it is open to persons to imagine that the greater unhealthiness of the riverside districts here may be due to the river itself, apart from the sewage it. What one would like to know is, whether it is the sewage in the river that makes the district unhealthy, or whether it is the river itself that does that?—I am afraid that I cannot answer that, except by saying that scarlet fever is very prevalent upon both sides of the river, which is not a thing which a low-lying district would have any special connexion with.

12,036. (*Sir P. Benson Maxwell.*) We have the fact that these are low-lying districts where your zymotic diseases are so high, and that they are also thickly populated?—They are not all thickly populated districts; those near London are.

*Prof. W. H. Corfield.*

14 March 1883

12,037. Those four instances, where the average is so much higher than that of London, are thickly populated places?—But I attach much more importance to the other districts than to the four first. I must, of course, attach much more importance to the districts below the sewer outfalls, and immediately about them, than to the first four districts which are really parts of East London.

12,038. (*Dr. Stevenson.*) Do you think that the emanations from the river cause there to be more scarlet fever, or cause it to be more fatal?—It is very likely that both those tests are true, but I cannot tell you as a matter of fact.

The witness withdrew.

SIR P. BENSON MAXWELL took the Chair.

Mr. BENJAMIN BROWNING, M.D., S.Sc. C. Edin. F.C.S. called in and examined.

12,039. (*Mr. Lumley Smith.*) I believe you are an M.D., and a member of several learned societies, and you are the officer of health for the vestry of Rotherhithe?—I am.

12,040. I believe you are also surgeon to two divisions of the metropolitan police, the "M," and the "Thames"?—I am to a subdivision of the "M" and to a sub-division of the Thames, the sub-division occupying the southern bank of the Thames.

12,041. You have given a good deal of attention I believe, also to matters connected with health?—I have for some years past as a medical officer of health.

12,042. You are a Fellow of the Sanitary Institution of Great Britain, and are upon the council of that society?—I am, and also on the council of the Social Science Association.

12,043. How long have you resided in the neighbourhood of the Thames?—For rather more than seven years.

12,044. Has that been at Rotherhithe?—The whole time.

12,045. During that time have you paid some attention to the condition of the Thames?—A good deal, having been connected with the sanitary department of my district, and with the Thames police for the whole of that time.

12,046. You have examined, have you not, for yourself, the water, and the mud of the Thames?—I have at different times and upon several occasions.

12,047. Have you from time to time taken samples of the water of the Thames for the purpose of examination?—I have.

12,048. Has that been done for the purpose of this inquiry, or for your own information?—It has been done for my own information, long before this inquiry was heard of, or at all events heard of by me.

12,049. Extending over what period?—Over the past five years.

12,050. Have you taken samples. I am not asking you for the details of your investigation at all; and have you examined them, and in what way?—I have examined them chemically, and microscopically.

12,051. Have you also from time to time considered how far you can trace any affection of the health of the people under your care to the condition of the river?—I have, having had under my care a large number of people who have attributed their illness to the smells arising from the river.

12,052. (*Chairman.*) You did not attribute it to that, but they did?—Yes, I did so in some cases where I investigated their statements.

12,053. (*Mr. Lumley Smith.*) Before I pass from this question will you tell me what number of police you have under your care?—I have 50 officers and men who live upon the south bank of the Thames, that is to say, of the Thames police, besides a large number of the land police.

*Mr. B. Browning, M.D., S.Sc. C. Edin. F.C.S.*

12,054. Have you in addition the medical care of any working men's clubs?—Yes, of a number of clubs, amounting to between 600 or 700 workmen in all.

12,055. What class of people are they composed of?—What we call waterside people, bargees, watermen, lightermen, boatmen, and people of that class.

12,056. So that you have a large number of waterside characters under your care?—I have.

12,057. Have you come to any general conclusions with regard to the effect of sewage as it is poured into the river?—I have.

12,058. What are the conclusions to which you, in your judgment, have come; will you give us them in succession?—The first conclusion to which I came was that a considerable portion of the sewage which is discharged into the river at the outfalls at Crossness and Barking is not carried down to the sea directly, but is brought up the river at least as high as Limehouse, if not higher. The second conclusion I arrived at was that whilst the sewage is thus retained in the river it undergoes decomposition, and becomes very injurious to health. The third conclusion was that the number of cases of various illness, such as fever, typhoid fever especially, scarlatina, various throat affections, general malaise, and sometimes diphtheria, as well as some cases of diarrhœa, are directly attributable to these emanations from this decomposed sewage.

12,059. And you have satisfied yourself of that after attending the patients and noticing the surrounding circumstances?—Yes, after attending the patients, and going out, in the case specially of the Thames police, by day and night at the same time of tide to which they said they had been exposed to those emanations.

12,060. With regard to persons subscribing to clubs, I suppose they are entitled to sick pay when they are ill?—Yes.

12,061. And their cases have to be investigated, have they not, to see if they are really genuine cases of illness?—Hardly that. I must accept their statements, or perhaps I might put it in this way. I of course investigate their case as a medical man, but as they are not in the same position to myself as the members of the police force, I put them upon the list, if they wish it, irrespective of my own judgment; but with the police it is different.

12,062. I presume you have kept no record of the individual cases amongst the clubs you attend?—No.

*Mr. B. Browning, M.D., S.Sc. C. Edin., F.C.S.*

14 March 1883.

I have only a list, which I have not very carefully kept, of the certificates that I have given that so and so was sick from such a time to such a time.

12,063. Now with regard to the Thames Police, what class of men are they with regard to age and physique and so on?—They are men in the prime of life carefully selected, of good physique generally, and with good hygienic surroundings in their houses; most of their houses are personally known to me. I have invariably made a rule of inspecting every house in my district in which police officers reside, should illness occur there.

12,064. Then they are people less likely than others to be affected by surrounding circumstances?—Undoubtedly.

12,065. Now with regard to the cases of illness, is there any temptation on their part to sham being ill when they are not?—It is quite the other way.

12,066. Why is that?—Because a considerable portion of their pay is stopped when they are ill.

12,067. They are fine strong young men, and they are fined when they are ill?—They are.

12,068. Have you found in the case of the police instances of illness or indisposition, which you attribute to the condition of the river?—Several.

12,069. Can you tell me about how many?—During the last 5 years out of an average strength of 50 men, who in those five years gave me 146 cases of illness from all causes, I have had 18 cases of various forms of illness, which were attributable, to the best of my judgment and in the belief of the men themselves, to the emanations to which they had been exposed while on duty on the river.

12,070. (*Sir John Code.*) Do you mean on the river or by the river?—On the river.

12,071. (*Dr. Stevenson.*) What part of the river do you refer to?—The part from London Bridge to Barking, the majority of my men being employed between London Bridge and Greenwich, but all of them being from time to time sent on duty as far as Barking.

12,072. (*Sir John Code.*) You attend all the river police, do you not?—I have one sub-division of river police and another of land police.

12,073. Have you found much difference between the river police and the land police?—Yes, in respect of illness. Although the Thames Police are the younger and stronger of the two, there is much more sickness amongst them than amongst the land police, the same conditions existing as to stoppage of pay when sick, and the hygienic conditions being about equal.

12,074. Could you give the Commission an idea of about in what ratio they would average one to the other?—Roughly, two to one. Out of every three policemen I have placed upon my sick list from the Thames and the M police, where I have one M policeman I am sure to have two Thames men.

12,075. Would that apply over the whole period during which they have been under your charge?—Yes, which is within a few months of seven years.

12,076. (*Mr. Lumley Smith.*) I understood you to say in speaking of these cases, which you attributed to emanations from the Thames, that you were not speaking of exposure to weather?—No, I have carefully eliminated all those. I have the particulars taken from my books if it is required of the exact maladies from which those men were suffering. (*A copy was handed to Mr. Bidder*).

12,077. You have told us you have seen the sewage ascending the river and so on; are you judging by the eye, or in what way do you judge?—I judge by the eye, smell, touch, also by the microscopical, and chemical evidence.

12,078. Have you taken any specimens of mud from the banks?—I have.

12,079. At what places?—At various places near the outfalls, and also as high up as Wapping, and at the Surrey Commercial Docks at Rotherhithe.

12,080. In what condition did you find the mud?—I found it black and very fœtid.

12,081. Did you find evidences of sewage?—To the best of my knowledge and microscopical observation, I did.

12,082. Do you find, going back to the question of health, that the health of your patients varies between summer and winter; do you find at any time of the year any symptoms of disease or illness which you attribute to the river?—Yes, in the hot months I get certain diseases both amongst my water police and amongst my club patients which I do not find at other periods of the year.

(*Mr. Bidder.*) Is not that true everywhere.

12,083. (*Mr. Lumley Smith.*) Are you able to compare those patients with the patients who live away from the river?—Yes.

12,084. Do you find those symptoms more prevalent or less prevalent with the people who are nearer the river than with those who are further back?—I find with regard to the police that while I am having these special complaints, which I have termed "riverine" complaints among the water police, the same complaints are not found among the land police; I find that amongst my club patients, whilst the lightermen and those employed upon the river, and also (in former years, not lately, since the Canal Boats Act has been passed) the children of bargees and those on canal boats plying on the river, are subject to "riverine" complaints, a similar class of people working in the docks, such as the Surrey Commercial Docks, seem to escape from those complaints.

12,085. What is the nature of those complaints?—A special form of sore throat, a great deal of malaise and languor, a sort of ill-defined fever, and more or less diarrhœa. I have found diphtheria distinctly attributable to it, and in some cases (where I was able to trace the cause), typhoid fever.

12,086. As you were able to trace the cause, what cause did you trace the typhoid fever to?—The typhoid fever has been evidently traceable to drinking the Thames water from alongside ships, which has been sometimes done.

12,087. Do you know the fever-rate in your parish; your parish is Rotherhithe, I suppose?—Yes; my parish is Rotherhithe.

12,088. That is a portion, is it not of one of the districts Dr. Corfield has been giving us?—That is a portion of the St. Olave District. I was looking at his tables, and I find he has not worked it out specially.

12,089. Can you give us the fever-rate in your parish?—The annual average of the zymotic death-rate, which I presume is what you mean by the fever-rate, has been for the last 10 years, from 1871 to 1880 inclusive, 3·83 per 1,000.

12,090. Is that high or low, as compared with the general average of London?—It is higher than many other corresponding riverine districts. I have not the figures, but it will be found from the reports relating to corresponding riverine districts, with a poorer population too, above London Bridge to be considerably higher than those.

12,091. It is rather below the whole of London as given by Dr. Corfield, but you say it is high as compared with what?—It is high as compared with some corresponding parishes higher up the river. The fact of its being below the average of London may be accounted for by the fact that I have succeeded in removing a great many cases to the hospital, so that the actual mortality in my parish has not been so much as it might have been.

12,092. I presume a great many of those cases of illness do not cause death?—No, they do not.

12,093. Have you any hospital in your district at all?—We have a large workhouse hospital making up, I believe, 400 beds, and receiving people from the whole of St. Olave's.

12,094. You have no fever hospital or anything of that sort?—No, not in my parish; the nearest is some distance beyond.

12,095. Then the fever cases in your parish you pass out of your parish to somewhere else?—A few

of them; those that I am able to obtain information of and to convey to hospital when necessary.

12,096. Of course every case of fever that goes away from your place and terminates fatally would of course decrease your fever death-rate?—Yes, of course; the bad cases I am unable to send; the slight ones I experience great difficulty in doing.

Cross-examined by Mr. BIDDER.

12,097. You are medical officer to the Thames Police?—I am, to one of the sub-divisions.

12,098. Have you anything to do with the "Royalist"?—No.

12,099. That is a vessel moored in the river?—I think you will find that she is on the bank and not moored at all.

12,100. Whereabouts is she located?—Below my district; she is on the river side; I have seen her often.

12,101. She is occupied by the Thames police, I believe?—By one or two; if there are four altogether, that as is many as there are.

12,102. Do you happen to know that their health is remarkably good?—No, it is quite the other way, I imagine, because I have had men coming thence and complaining of the situation.

12,103. Have you anything to do with the inspection of the "Royalist"?—No; but have often had men who have been in the "Royalist," who have been transferred to my division, and I have noted that they have not been in good health. One of the cases I gave you a list of came from there.

12,104. You handed me a list, this is an extract from a book; would there be any difficulty in producing the original book?—I think so. Orders are given to the inspectors and superintendent, that it is to be kept at the police station; it is taken to my house every morning, and when it is done with it is brought back again.

12,105. (*Chairman.*) There would be no objection, would there, to letting Mr. Bidder see the book if he wishes it?—I have nothing to do with it; the book is not in my custody, it is in the custody of the Superintendent of Police.

12,106. (*Mr. Bidder.*) These figures are spread over five years?—Yes.

12,107. And you picked those out of 146 cases referring to the Thames Police?—Yes.

12,108. Last year you were only able to find two cases which you could in any way attribute to the river?—Yes.

12,109. One of those was an abscess?—Yes, one was a case of abscess and blood poisoning.

12,110. Is an abscess a thing that could fairly be attributed to the Thames?—Most certainly, when, as in this case, it is the result of blood poisoning which I and the patient attributed to the inhalation of various smells.

12,111. Which came first, the abscess or the symptoms of blood poisoning?—The symptoms of blood poisoning.

12,112. I do not know much about it, but I have heard of blood poisoning in people who do not live near the river Thames; does that happen?—No doubt it does in people affected by the special poisons that produce blood poisoning.

12,113. I see that in the whole five years you only had five cases of blood poisoning and one of them was a case of dyspepsia?—Certainly; blood poisoning, as a rule, does not affect strong healthy men. Their *vis vitæ* enables them to escape in many instances, even when exposed to its influencing causes.

12,114. Have you cases of blood poisoning in your land police?—I do not remember one.

12,115. Have you a similar record of their cases?—I have a similar record of their cases.

12,116. Upon what ground do you make the statement, and upon what statistics that you have two cases of sickness amongst the Thames police for one amongst the land police?—I stated that it was a rough calculation, and from memory.

12,117. Rough or not, a calculation implies figures you know?—No doubt. That idea is taken from the sick books of the two divisions.

12,118. What were the figures with regard to the two divisions?—I have not worked up the land figures. I cannot say at the moment, but I know as a fact that that is about how they average.

12,119. You cannot know that as a fact unless you have worked it out?—We know many things as absolute facts in every capacity of life which we may not be able to give the exact figure for on the spur of the moment.

12,120. Do not let us waste time in dealing with truisms. As a matter of fact, for instance, how many cases have you had in the land division in the last five years?—That I cannot say upon the spur of the moment; I have not added them up, but they are very much fewer than in the Thames Police Sub-division.

12,121. How many men have you in your land division?—Nearly 100; between 80 and 90.

12,122. You have also, I presume, no objection to our inspecting that book?—I have nothing to say to it; it is not in my custody, and never is; it will be a question for the Commissioner of Police.

12,123. You have stated that you have had two cases of sickness amongst the Thames police to one amongst the land police; now I ask for the figures upon which you base that statement?—If I had known the question would have been asked I should have been most happy to have extracted the figures and sent them in.

12,124. With regard to the two cases of blood poisoning I am glad to see they were not very serious; one gentleman was back at his work at the end of the week and the other after no very long time?—In both cases the men had been ill before they were put upon the list.

12,125. Now you used the term malaise; I am not a doctor; what sort of disease is that?—I think, though it is difficult to define positively what it is, we most of us know what it is. If I were obliged to translate it I should describe it as being a condition of "alloverishness."

12,126. It is, I believe, sometimes used to describe the feelings of a gentleman who has been out to an entertainment the night before. When the Noxious Vapours Commission was sitting the term was used to describe the condition produced by the exhalations of factories and things of that kind?—That I cannot say, as I was not connected with that Commission.

12,127. You have a good many factories in Rotherhithe, have you not?—I cannot say that we have many.

12,128. There are a good many in Rotherhithe and Bermondsey, are there not?—The Bermondsey factories lie a long way from the river.

12,129. Those 18 cases are the entire number of cases of sickness you could in any way attribute to the influence of the river amongst 50 men in five years?—Not in our view; I have carefully eliminated all doubtful cases.

12,130. Those are all the cases you could put down as being attributable to the river?—Those were all the cases which I was quite clear were brought about by the emanations from the river.

12,131. (*Sir John Coode.*) If you say you are quite clear about those 18 cases, how many doubtful cases would there have been?—I should say quite half as many again.

12,132. Now here is another case—"stomach and liver disease." I am talking about a thing that I do not understand, but is that a sort of thing that comes from a bad smell in the river?—That is a case which I have only shown once,—a case of derangement of

*Mr. B. Browning, M.D., S.Sc. C.Edin., F.C.S.*

14 March 1883.

the stomach and derangement of the functions of the liver,—the symptoms were apparently due to the derangement of the functions of the liver and stomach, which I could attribute to nothing else but exposure to the smell of the River Thames, that case is shown as one case only; it should really have been shown as six or seven cases, for the man was upon the list six or seven times in addition to that entry, and for the same ailment.

12,133. If you tell me that stomach and liver diseases are likely to arise from a river smell I will believe you implicitly?—In this case there can be no doubt about it.

12,134. Another gentleman had stomach disease, that was attributed to the river?—Yes, that case was so serious, and lasted so long, that he was discharged from the service in consequence.

12,135. There are several gentlemen who suffer from diarrhœa in the summer months; how are you certain that that is attributable to the river, and not to the many causes which do produce diarrhœa to persons who are not upon the river during the summer months?—The men were in good health, and had not committed any error of diet.

12,136. How do you know that?—From their statements.

12,137. That is a strong statement to make; their views of diet might not be identical with yours?—I took it from their statement of what they had eaten.

12,138. Did they say what they had drunk?—In that list I have put down no case of diarrhœa unless a man was or professed to be a teetotaller.

12,139. But sometimes that is a cause of diarrhœa, is it not?—Not to my knowledge.

12,140. Now I see that another of the 18 cases is put down as gastritis, is that a sort of thing which is likely to come from a river emanation; if you say it is I will believe it?—There was irritation of the stomach which is one of the complaints that may fairly be attributable to the sewage emanations, and this man had been employed in the lower part of the Thames at low tide, and complained very much of the smell of the banks.

12,141. (*Mr. De Chaumont.*) Was he a teetotaller too?—Yes.

12,142. (*Mr. Bidder.*) Are the teetotallers in the police like six-day cabs marked with a particular kind of number?—No; they have simply their divisional number, which is precisely the same whether they are total abstainers or otherwise.

12,143. You say you find that the people who work in the docks are, as compared with others, particularly free from this disease?—I find that the people who work in the docks at the same time in the summer, members of the same clubs as I have spoken about, working about over the water all day long, but being simply in the docks and not employed up and down the river at different times of the tide, are free from these stomach affections.

12,144. What do you attribute that to?—I believe there are certain special affections which are produced by the emanations from the river, and that the people not exposed to those emanations do not contract those diseases.

12,145. I suppose you are speaking of the Surrey Commercial Docks?—Yes.

12,146. Are you aware that the docks are filled with their water from the river?—I am. I see it running in there from time to time.

12,147. And at high water when, if ever, it is most charged with sewage from below?—I do not know that; I simply know that they are filled from the river at high water.

12,148. If it is true that the river in your neighbourhood is polluted by our outfalls, the pollution must be principally at high water, and not at low water?—I do not think so.

12,149. I suppose you know that at low water, the water that comes down comes from above, but at high water it comes from below?—Yes, so it does; at the turn of the ebb tide; it comes from below at the end of low water with a young flood, and then I believe at young flood most of the pollution is brought up.

12,150. (*Mr. Abernethy.*) You refer to the Surrey Commercial Docks, do you not?—I refer to the Surrey Commercial Docks simply. I know nothing of any docks upon the north side of the river.

12,151. (*Mr. Bidder.*) Now with reference to typhoid fever, you have had a certain number of deaths from typhoid fever in the Rotherhithe District, have you not?—Yes.

12,152. Is it the fact that none of those deaths occurred in the district immediately contiguous to the river, but farther back; for instance you know Rotherhithe Street—that is a long street that runs parallel to the river, is it not?—Yes.

12,153. Is it the fact that all the deaths from typhoid fever occurred farther away from the river?—I cannot say that. I think Rotherhithe Street has always had its fair share of mortality of all sorts.

12,154. Now I see that you as a medical officer of health indulge in an annual report like other people?—To the limited extent permitted me by the vestry.

12,155. I am sorry to hear that your vestry does not allow you carte blanche, but to that limited extent I see that you avail yourself of it. I have one dated the 31st of December 1879; is that the last you made?—No, I have written three since then.

12,156. You begin by saying, "I will remind you "that in 1856 Rotherhithe was supposed to be one "of the most insalubrious suburban districts, being "almost entirely unsewered, marshy, with a scanty "water supply, and that so contaminated, as to be "usually refused even by horses."

12,157. (*Chairman.*) Was that so?—It was not within my own knowledge, but I took it from the reports of my predecessors.

12,157. (*Mr. Bidder.*) A great deal of that has been changed, but what I want to come to is that the marsh still exists, does it not?—No; it has been done away with.

12,159. You have not raised Rotherhithe bodily, have you?—No, but from time to time the marsh has been drained as it was built over.

12,160. (*Sir John Coode.*) When was that drainage carried out?—From 1856 to the present date.

12,161. Spread over the whole period?—From then down to the present time, till now when there is not a quarter of an acre of it that is not drained.

12,162. But it must have been done very gradually, if it was spread over that time?—The Vestry Reports give the proportions in which it was completed.

12,162. (*Dr. Stevenson.*) But when would it have been practically finished?—Not until now, because Rotherhithe has been very much built over lately, and of course house drains are not made until houses are built.

12,163. (*Sir John Coode.*) Then it has not been a regular system of drainage undertaken and carried out, but as the buildings were built so the drainage proceeded?—Precisely.

12,165. I understood that there had been one broad system of drainage regularly undertaken and carried out, but you mean to say it was carried out gradually as the buildings were completed?—Precisely the house drainage.

12,166. (*Mr. Bidder.*) Now will you let me ask you if this is correct, that—"The gross death-rate "was 23·2 per thousand per annum, but the large "number of non-residential deaths recorded (owing "to the reception of paupers from other districts into "the St. Olave's Workhouse, the frequent accidents "occurring to strangers in the Docks, and the many "bodies from the Thames which you have to receive "and inter) greatly reduced this, and following the "method pursued by both my predecessors, I have "computed the 'corrected death-rate' of 1878, as "18·8 per thousand." Is that correct?—Yes.

12,167. I see you have added a very useful note that you can turn the rate per 1,000 into a percentage

by simply moving the decimal point one place to the left?—For the edification of my masters following the example of the Registrar General.

12,168. "Whilst therefore our total corrected death "and child rates have diminished since 1877, and the "former is lower than in either London or Greater "London, last year's metropolitan death rate is higher "since 1877 by 1·6 per 1,000, and the mean of the "23 large towns by 1·4 per 1,000. In the same "period our mortality was but 2·6 per 1,000 beyond "that of the healthiest large town mentioned by the "Registrar-General (Dover, with a death rate of "16·2), and 10·8 per thousand lower than the most "sickly (Dublin, with 29·6)." "Rotherhithe, you "will probably agree with me, is not insalubrious." Is that your opinion still?—Quite so from these figures; these figures merely give the death rate; the death rate is one thing and the sickness rate is another.

12,169. No doubt, but a statement is a statement, and I ask you whether you still adhere to that statement, and invite us to agree with you that Rotherhithe is not insalubrious?—That is so.

12,170. That is your opinion still that Rotherhithe is not insalubrious?—I am still of opinion that Rotherhithe is not insalubrious as far as regards the death rate.

12,171. We know what insalubrious means,—everybody knows what that means. By the bye you have added certain things, and I must ask you a question that will militate with your death rate, but has nothing to do with the main drainage outfalls; for instance I see you mention a well-known piece of stagnant water, called "the mill dam," which you say was in a very offensive condition?—Quite so; if you will read on further you will find that in that year it was piped and drained and put into repair, and it is now abolished altogether, it is not in existence at present; you are speaking about 1878. This Report goes back to 1878, and many improvements have been made since. This mill dam was one of them, and that has been emptied within the last quarter, but at the time of that report it was just being put into a proper condition, the sewage was being diverted from it, and it was being systematically cleansed and so on.

12,172. Another thing I see which has some bearing upon the question is that the water of which you took samples near Rotherhithe you found polluted sometimes?—Certainly.

12,173. Let me ask you if this correct, "My atten- "tion was next directed under the "Rivers Pollution "Act, 1876," to the numerous privies and drains dis- "charging into the Thames, and with your sanction "preliminary steps were instituted for their removal." That leads me to ask you is it the case that there are instances where there are numerous privies and drains discharging into the river?—No, all those that you have been referring to have been cut off.

12,174. Have they all been cut off?—They have now, but that report was written in the beginning of 1879.

12,175. All you say in your report is that you have taken some preliminary steps for their removal, so I gather from those words that their removal is something accomplished since then?—That was so.

12,176. I see another thing you describe with great eloquence: "A horrible and dangerous nuisance, "caused by a person, named Judd, collecting, to an "enormous extent, fish refuse for manure making in "several arches of the South-eastern Railway (and "mentioned by the Local Government Board In- "spector in his First Report on Noxious Trades,) "was partially put down."——

12,177. (*Chairman.*) But that was in 1878; has that been put down?—Yes, but that was not upon the banks of the river.

12,178. (*Mr. Bidder.*) I see we have not quite got rid of Judd, because he is described as occupying premises and collecting garbage there?—At present he is occupying a cell in one of Her Majesty's gaols.

12,179. Then that is something recent; now will you tell us what your death rate was for last year?—I can tell you what it was for the year 1881. I have not been called upon for my report for 1882 yet.

12,180. What was the death-rate for 1881?—I think the corrected death-rate was 18·7.

12,181. That is a little bit better than this very excellent year?—Yes, but that is the death-rate and not the sickness rate; all my evidence as to this river illness relates to sickness; I have not a single case of death to refer to.

12,182. (*Sir John Coode.*) Can you hand us any statistics as to the sickness rate?—No, it is quite out of the question, because so much sickness, especially zymotic sickness, is so carefully concealed that any statement I could prepare would be perfectly valueless; it would not even give an account of the sickness among the pauper population.

12,183. Have you any of your later reports?—There are three more printed, another is in the printer's hands.

12,184. I see that you attribute a good deal of the illness that you have to the "concealment of mur- "derous ailments like small-pox, scarlet fever, diph- "theria, and so on systematically in better families "encouraged by advisers from whom better counsel "might have been expected"?—Yes.

12,185. I have been looking through your report, and I do not find in your report of the district any suggestion whatever that any of the illness of the district is attributable to the Thames?—Certainly not; that report was written for the vestry.

12,186. Do you not tell them the truth at the vestry?—I do, but I do not always tell them the whole truth; they do not want to be told.

12,187. (*Chairman.*) Was not it part of your duty to call attention to the causes of disease in your report?—To a certain extent it was, but I have always found that if I presumed to offer anything but limited advice in my report they usually refused to accept it.

12,188. (*Sir John Coode.*) When you say to a certain extent you reported to the vestry, where do you draw the line between what you report and what you do not report; you report facts simply, do you not?—I report facts.

12,189. And you abstain from giving advice or calling attention to the causes of certain effects?—Not altogether, but I find that if I make a statement having reference to the duties of other bodies my vestry decline to go into that.

12,190. (*Mr. Bidder.*) But I find you go pretty largely into causes?—As far as I consider they come under the province of my vestry I do.

12,191. You point out all sorts of causes of disease, but you never suggest that any are attributable to the river?—That is so.

(*Chairman.*) You do point to other causes of disease?—Yes.

(*Mr. Lumley Smith.*) Those were the causes which were under the control of the vestry.

(*Mr. Bidder.*) Not all of them.

12,192. (*Sir John Coode.*) I presume that is what the witness means?—I mean that decidedly.

12,193. (*Chairman.*) You mean that in pointing out the causes of disease you limit yourself to causes which are under the control of the vestry?—That is so, and were I to do otherwise the vestry would not appreciate it; they do not want to be brought into collision with other bodies.

12,194. (*Mr. Bidder.*) For instance, the way in which people conceal disease is hardly within the province of the vestry, is it; they can do nothing to check the concealment of disease. And again, I find you go out of your way to describe causes in which you say the vestry can do nothing, you say, "I made "the customary half-yearly inspection of slaughter- "houses and cow-houses," and so on, and having suggested an improvement you go on to say that "the "sanitary authority are powerless to effect such an "alteration"; that is one case in which you did go

*Mr. B. Browning, M.D., S.Sc. C.Edin., F.R.S.*

14 March 1883.

" outside your authority?—That is one of the occasions on which I was politely warned to mind my own business when mentioning such a body (as I did) as the Metropolitan Board of Works. Several members of the vestry told me plainly that I had nothing to do with the question of the Board's powers—nor with the registration of disease.

12,195. (*Dr. Stevenson.*) But surely the vestry have to do with the licensing of cow-sheds?—Nominally, but really it is only a farce; they will not take an active part in the matter.

12,196. Do not your subordinate officers examine the cow-sheds?—Yes, and I do myself, but still it is a perfectly useless thing for me to do, since my recommendations are not always acted on.

12,197. It is a part of your duty?—Yes, it is a part of my duty.

12,198. (*Mr. Bidder.*) You told me just now that all these privies and drains in your district running into the Thames had been stopped up?—Yes, I told you that as far as I knew they had been.

12,199. Are you aware that in his report for 1881 Mr. Collingridge reports 19 foul outfalls within your district of Rotherhithe?—I am not aware that he did so, and I think with all deference to him that they did not exist in 1881, where I specially examined the Rotherhithe foreshore looking for them; I will not say they have not been again opened since.

Re-examined by Mr. Lumley Smith.

12,200. One word upon the list of cases which you handed my learned friend; you stated in answer to me, that there were only two cases in 1882; that is so, is it not?—That is so of cases which I could distinctly attribute to the river.

12,201. That was a very cold year, was it not?—That was a very cold year.

12,202. You find, as I understand, no cases that you can absolutely attribute to the river in the months of November, December, January, and February?—That is so, with one exception, where a man who, I think, afterwards left the service, was taken ill in March, but he had been to me several times before that; in the previous autumn he had been to me.

12,203. (*Chairman.*) With that exception there were no cases upon the list mentioned by Mr. Lumley Smith?—I think not. There is one more in the month of February, but that man had been to me several times in the previous autumn. I might have made that list much larger if I had put down the same men two or three times over, which I might have done, as they have often come back.

12,204. (*Mr. Lumley Smith.*) Now I will ask you one general question with regard to typhoid fever; you have no typhoid case there?—No.

12,205. Is it the fact that typhoid fever comes usually from drinking contaminated water, and not from emanations from the river; is that a fact or not?—I believe as a rule typhoid fever is brought on by drinking poisoned water. I mean water poisoned with the " contagium " of that fever.

12,206. Now with regard to Rotherhithe being salubrious; are some parts of Rotherhithe more salubrious than others?—Yes, of course the more open and better built parts are more healthy than the poorer and more crowded parts.

12,207. Comparing the parts near the river with the other parts, which are the most healthy?—The parts farther back, decidedly.

12,208. With regard to your nuisances, you do not agree that there are 19 foul outfalls in your district?—I am not aware of them.

12,209. The only nuisance left is the Thames?—I think that is the chief nuisance.

The witness withdrew.

Professor John Thomas Way, F.C.S., recalled; further examined by Mr. Balfour Browne.

*Prof. J. T. Way, F.C.S.*

12,210. You are aware, I think, of the various estimates which are formed by the engineers of the proportion in which sewage may at any time be present in the river?—Yes, I have heard the evidence.

12,211. Will you tell us what proportion of sewage in the water would, in your opinion, make it so foul as to become a nuisance?—I should say that from three to five per cent. would certainly make it foul.

12,212. (*Professor Williamson.*) May I ask, have you made a mixture of sewage with water in known proportions, and taken occasion to observe the properties of this mixture, and can you say whether the opinion you have expressed is founded upon definite observations?—It is. You well know I have been engaged upon sewage questions all my life, for the last 40 years, and I have had, I think, quite as great opportunities as any other chemist of dealing with sewage; therefore, when I speak I do not speak from any individual experiment, but from a general knowledge of the subject, that has been done over and over again.

12,213. You have found mixtures in such proportions as those to be offensive?—Yes, in my laboratory at this moment I have a mixture of 10 per cent., but that is a very offensive mixture.

12,214. (*Chairman.*) You say that from three to five per cent. also would be a nuisance?—Yes.

12,215. (*Mr. Balfour Browne.*) Assuming that from three to five per cent. is poured into a river, even of the same bulk as the Thames, at the outfall, you think it would become a nuisance?—The larger the bulk the greater the nuisance. I think the quantity poured in, which is a known quantity, is very large for a river of the size even of the Thames, which is a large river.

12,216. The total weight of offensive matter which you say is discharged into the Thames is, as you say, very considerable?—Yes; I have made a great number of analyses of the sewage of the Thames; there were a number which were made for the Metropolitan Board of Works, which I do not believe are published, but they were made, and made very carefully. They were made for the Metropolitan Board of Works in connexion with the International Financial Society, in connexion with the Essex Reclamation.

12,217. What is important in this connexion is, as I understand, to tell what is becoming of the sewage so discharged?—Yes.

12,218. Have you directed your attention to that; do you think the liquid portion is the most important portion to consider?—I do not consider it so.

12,219. Would you just say why?—Sewage may be roughly divided into three parts; the liquid portion, the heavy part which comes from the detritus of the streets, and the light flocculent part, which, in great measure, comes from the fæces, the indigestible portion of the fæces. The greater part of the light floating matter, no doubt, comes from the fæcal matter of the body.

12,220. Is there some of the matter soluble, and some insoluble?—Of natural fæces, as discharged from the body, there is a portion soluble in water, it is not a large portion, perhaps 10 per cent., the rest is insoluble.

12,221. Of the history of the insoluble is much known at the present time?—Its composition and its character, of course, are well known, but what becomes of it in the river, especially in a tidal river like the Thames, cannot be known, simply because it is partly swept away with the liquid, and partly subsides.

12,222. With regard to the insoluble matter, what do you mean precisely by that term?—I prefer to take sewage as if it were nothing but fæces and urine, for, practically, that is what it is. Of course all sorts of other things get in, but as compared to those two sources, the other sources are very small indeed.

12,223. (*Sir John Coode.*) And comparatively harmless, would you say?—I do not say that at all, because there are all sorts of nastinesses get in, but taking it in the gross, and taking a common sense view of sewage, I think that is a fair way to look at it.

12,224. (*Mr. Balfour Browne.*) For the purpose of your calculation you are leaving out of consideration all the road detritus and débris?—Yes.

12,225. For the purpose of discovering what causes shoals in a river, that might be very important?—It would be very important.

12,226. But as regard nuisance to health that is unimportant?—It is quite unimportant how far the discharge into the river goes, except so far as regards that which is organic. Of road detritus, I do not care what proportion is discharged; I prefer to get at it by seeing how many people contribute to the sewage.

12,227. Upon that point you made an investigation to find out how much substance passed from the body; that was referred to by Dr. Tidy, but you can give us the substance of it?—I calculated from the results of observers generally, and from some of my own, that the quantity of solid fæces about which I am speaking now, per head of the population was 1,750 grains, which is a quarter of a pound.

12,228. Of solid excrement?—Yes, of solid excrement in a liquid state, that is to say with its water.

12,229. (*Sir John Coode.*) Is that per head?—Taking the average of every head of the population daily.

12,230. (*Mr. Balfour Browne.*) Of this quarter of of a pound, how much is actually dry matter?—One-fourth of it.

12,231. Twenty-five per cent. is actually dry matter when the moisture has been god rid of by drying?—Yes.

12,232. That makes it an ounce of dry fæces per head per day?—Yes.

12,333. Under these circumstances every 16 persons would contribute one pound?—Certainly.

12,234. And every 100 persons 6¼ lbs.?—Yes.

12,235. Have you calculated how much under these circumstances of dry fæces would be sent into the Thames per day?—Take the figure as you gave it just now of 16 persons to one pound, it is very easy to see that there would be at that rate, taking the population roughly at 4,000,000. (I wish it to be understood that these are quite rough figures. I do not see any use in pretending to get the figures with minute accuracy), it makes it 110 tons for the whole population of London per day of dry fæces.

12,236. And taking the dry and the moist together, it would be over 400 tons?—Yes, but that is not quite what I am endeavouring to lay before the Commission. The quantity I have stated is dry matter of fæces, but of course there is no dry matter of fæces in practice; it is merely to give the figure which has been asked for, but the dry matter is not what you have to do with; therefore the next estimate is that four times that is what would be the real quantity of wet fæces that found its way into the river, which gives you 1,000,000 lbs. or 400 tons of actual fæces a day; that is to say, fæces, which, if stirred up in a great lake would remain 400 tons of solid matter floating about.

12,237. (*Chairman.*) I make it 440 tons?—I take the 40 tons off for the soluble constituents.

12,238. You take it at 400 tons, allowing for the loss of the soluble constituents?—Yes, that figure I may say of a quarter of a pound per individual has been very much adopted; many methods have been attempted to find out the quantity.

12,239. We had some German authorities cited before us?—Yes, but amongst others, Mr. Lawes and Dr. Gilbert, whose names are known to the Commission, attempted to determine the quantity of sewage of a town by reference to the food, and what became of that food; that is to say, a statistical and physiological inquiry, and they came to very much the same results. There were books and volumes of reports, as you know, upon these subjects. That and the attempt to determine by actual experiment, collecting the sewage, are two methods; the third is to take simply the solid and liquid excrement, and make a fair guess at it, and calculate from it; that is the one I have adopted.

12,240. (*Mr. Balfour Browne.*) Seeing, as you believe, that that is the actual amount thrown in every day, is that, to your mind, a very startling amount to be turned in a river, even of the volume and size of the Thames?—It is an enormous amount; take a simple calculation; 400 tons or 400 cart loads; if you distribute that over the whole 24 hours, you find that there is a cart load going every three minutes. I do not believe the public would have borne it if it could see it. It is the fact that it goes in in a manner that is unseen—

*Mr. Bidder* objected to the evidence as being beyond the scope of the witness.

12,241. (*Mr. Balfour Browne.*) What, in your opinion, becomes of the insoluable or organic matter of the sewage, because that, you say, is the most important matter to be considered in this inquiry?—I think the light flocculent matter, when it is discharged into the river, moves up and down with the tides, depositing its heavier portions. It gradually meets with the actual mud or clay of the bottom, which has a strong tendency to combine with it. Aluminous matters have a tendency to combine with organic matter; so it becomes heavier and sinks, especially in slacks and places where the banks are formed; and in that way a great deal of the solid matter fails to go with the liquid matter; so that in fact it must be accumulating at the bottom of the river. I think, also, in fact I know, that if you shake up some mud that has been collected from the bottom of the river it settles very much faster than ordinary sewage.

12,242. Do you know whether there are large deposits of this organic mud, if we might so call it, at the bottom of the river?—Yes, I know there are, because I have seen them; of course I do not know anything about their quantity, or anything of the kind.

12,243. But you know it is there, and you say that, chemically, the light organic matter is apt to combine with the aluminous matter and sink?—Yes.

12,244. Is it your opinion that this mud is a more serious source of nuisance than the soluble part of the sewage that you have been mentioning?—I do, for this reason, because the soluble part (at what rate I do not know, because I have not heard the engineers' evidence, nor read it), is sooner or later taken away with the water of the river; but it would not at all surprise me that a very large proportion of this fæcal matter is collecting at the bottom of the river in different places. What happens is this. Supposing it to be once collected, it undergoes fermentation there, and produces gases which are some of the most noxious and objectionable; the nastiest gases at all events, of any organic matter; and when that mud is stirred, it comes up and gives off that gas. It goes down again to the bottom, and produces more, and it must go on doing that until it is entirely destroyed in whatever time that may take up. But the liquid matter of sewage is already in a state very far advanced in oxidation, it is on the point of passing into other materials which are not objectionable gases. It smells very nastily at first, but the oxidation undoubtedly destroys it. You will see that in this way, if you take some sewage and water, and pour it into a deep vessel, and stand it in a warm room, after a day

*Prof. J. T. Way, F.C.S.*

14 March 1883.

or two it will cease to smell, that is to say, the nastiness at the top getting oxidised without smell. If you pour off the liquid, and then stir up the little drop of liquid pure sewage at the bottom, you get an abominable smell at once; that is to say, that all the while the solid refuse is going on decomposing and producing noxious gases.

12,245. To follow out the description of that experiment, would this mud in the Thames be much more offensive when it was stirred up?—Undoubtedly, it only becomes offensive when it is stirred up, or when the gases escape by themselves.

12,246. At what time of the year do the gases escape more readily?—In the four or five warm months in the year. You positively see the black mud coming up to the top of the river, and the bubbles exploding; so also in stagnant ponds, you see the black mud which is produced in the same way.

12,247. This theory of yours that the solid organic material of the sewage is more productive of injury than the liquid, is not a new theory at all, but has been produced by you in a report as long ago as 1854, which you wrote to the Royal Agricultural Society?—That was so.

12,248. And you have seen no cause to change that theory up to the present?—No, I believe fully, it is perfectly well known, that the deposits upon the banks of the river were the cause of the stench. When the river was full there was not nearly so much smell.

12,249. Even although at the present time there may be no smell from the river at all, would the mud at the bottom of the river be in such a condition that when the warm weather came and brought it to the surface, the nuisance would then arise?—Yes.

12,250. Is it your view that under these circumstances, seeing that we have had evidence that the mud is accumulating, the condition of the river will be a very serious matter in years to come?

12,251. (*Chairman.*) Perhaps we had better say, if it should go on accumulating, will it, in your opinion, become a serious matter. I think the witness's opinion is that it is very bad at the present time and we may assume that if it becomes worse he will be of that opinion still?—That is so.

12,252. (*Mr. Balfour Browne.*) I believe you want to make a correction in your chlorine tables?—Yes, it is a correction in the lithograph table, the resumé of the chlorine experiments. At Deptford in the upper part of the table, the chlorine at low water is put down at 4·9, instead of 49·0; that has been corrected in some of the copies, but where it is repeated at the bottom of the table the error has not been corrected.

12,253. You thought that upon the last occasion the relation of chlorine in sea-water, sewage, and river water, was not made clear enough; have you any thing to add as to what you said as to that?—I am not aware that I said much about it at that time, but I would point out that as the experiments upon chlorine were mainly intended to see where sea water and where river water was in the river it was absolutely necessary therefore that they should be correct, and that therefore the question of the influence of the chlorine in sewage upon the quantity, should be taken into account; I wanted to point out that I had myself not taken it into account, and for this very simple reason. The chlorine in the river water is in 100,000 parts something less than two.

12,254. (*Chairman.*) 1·7?—Yes, 1·7; the proportion of chlorine in the sewage is certainly not more than 20. Dr. Frankland and Dr. Tidy put it down at 10. My impression is that it is higher than that, but it is certainly not more than 20, and the chlorine in sea-water is nearly 2,000. I think it would be seen that that if you were to take an equal mixture of sewage—take 100,000 parts of sewage containing 20, and 100,000 parts parts of salt water, you would have in the one case 2,000, and in the other 20. In the half of that, that is, in 100,000 parts, you would have 10 from the sewage, and, say, 1,990 from the sea-water; so it makes no kind of difference; so that the proportion of chlorine in the river water is practical evidence of the quantity of sea water at that point.

12,255. The greatness of the difference in the chlorine between the river water and the sea water makes it impossible that the chlorine test can go astray?—Yes, quite so; the difference between the 10 and the 20, as compared with the proportion in sea water would be very little more than the error of analysis.

12,256. Now, have you a table of the analyses of various samples of water taken between Teddington and Southend, showing the solid residue?—Yes (*producing a table*).

12,257. I see that the samples were taken at the surface and at deep water respectively, and at high water and low water?—Yes.

12,258. What does this show to your mind?—I do not know that it proves anything to my mind; it is only the solid residues of the same samples of water that were collected.

12,259. (*Mr. Bidder.*) Those are water samples and not mud samples, I believe?—They are water samples, but they are total solid residues in the same waters as were examined for chlorine, and which are described in the first and second pages.

12,260. (*Mr. Balfour Browne.*) These show, upon the 14th and 22nd of September, the residues of the very same water that you described before?—Yes.

*The same were handed in and were as follows:*

SOLID RESIDUES in Samples.

*Collected 14th September* 1882.

| | High Water. | | Low Water. | |
|---|---|---|---|---|
| | S. | D. | S. | D. |
| Teddington - - | 30· | 29· | 29·5 | 30· |
| Chiswick - - | 29·5 | 29·5 | 35·5 | 41·0 |
| St. Paul's Pier - | 460· | 485· | 33· | 32· |
| Deptford - - | 915· | 965· | 105· | 110· |
| North Woolwich - | 1380· | 1410· | 345· | 415· |
| Barking - - | 1565· | 1595· | 590· | 700· |
| Crossness - - | 1850· | 1900· | 1030· | 1100· |
| Erith - - | 2131· | 2040· | 1065· | 1100· |
| Gravesend - - | 3050· | 3165· | 2120· | 2230· |
| Southend (end of Pier) | 3940· | 3940· | 3740· | 3680· |

The figures are parts in 100·000.
The letters S and D mean that the Sample was taken near the surface or deep respectively.

SOLID RESIDUES (parts per 100·000) in Samples.

*Collected 22nd September* 1882.

| | High Water. | | Low Water. | |
|---|---|---|---|---|
| | *S. | D. | S. | D. |
| Teddington - - | 30· | 30· | 28· | 28·5 |
| Chiswick - - | 28· | 30· | 30· | 29·5 |
| St. Paul's Pier - | 209· | 210· | 32· | 31· |
| Deptford - - | 650· | 695· | 82·5 | 80· |
| North Woolwich - | 1195· | 1220· | 355· | 370· |
| Barking - - | 1330· | 1380· | 610· | 680· |
| Crossness - - | 1480· | 1620· | 910· | 980· |
| Erith - - | 1790· | 1860· | 1160· | 1180· |
| Gravesend - - | 2790· | 2855· | 2280· | 2210· |
| Southend (end of Pier) | 3960· | 3880· | 3740· | 3780· |

* S means near surface.
D means deep.

12,261. (*Mr. Bidder.*) Combining suspension and solution?—No, they do not; they show the solid residues in the filtered water.

12,262. Then they are matters in solution only?—Yes.

12,263. Matter which becomes solid by evaporation?—Yes.

12,264. (*Mr. Balfour Browne.*) Have you also a table showing some determinations made by Professor Wanklyn's method of analysis?—I have.

12,265. That shows analyses of water taken at the same places from Teddington to Southend on the same dates?—Yes, they were taken partly upon the 14th and partly upon the 22nd of September.

*The same was handed in and was as follows:—*

DETERMINATIONS by WANKLYN'S METHOD.

Samples taken on the 14th and 22nd September.

| | Free Ammonia. | Albumenoid Ammonia. |
|---|---|---|
| | Parts per Million. | |
| Teddington - September 14, L.W. deep | ·026 | ·130 |
| Teddington - September 14, H.W. deep | ·040 | ·120 |
| St. Paul's Pier - September 14, L.W. deep | ·020 | ·120 |
| St. Paul's Pier - September 14, H.W. deep | ·120 | ·180 |
| Deptford - September 14, L.W. deep | ·060 | ·120 |
| Deptford - September 14, H.W. deep | ·080 | ·200 |
| North Woolwich. September 22, L.W. deep | ·120 | ·200 |
| North Woolwich. September 22, H.W. deep | 1·200 | 1·040 |
| Barking - September 14, L.W., 1 foot from surface. | ·026 | ·260 |
| Barking - September 22, L.W. deep | ·040 | ·240 |
| Crossness - September 14, L.W. deep | 3·400 | ·320 |
| Crossness - September 14, H.W. deep | ·080 | ·240 |
| Crossness - September 22, L.W. shallow | 2·600 | ·240 |
| Erith - September 14, L.W. shallow | ·120 | ·240 |
| Erith - September 22, H.W. shallow | ·008 | ·210 |
| Gravesend - September 14, H.W. deep | ·060 | ·090 |
| Gravesend - September 14, L.W. deep | ·080 | ·160 |
| Southend - September 14, H.W. deep | ·160 | ·090 |
| Southend - September 14, L.W. deep | ·060 | ·120 |
| Southend - September 22, H.W. deep | ·026 | ·060 |

J. T. WAY.

12,266. (*Mr. Bidder.*) Were the samples taken by you?—No, but they have been proved.

12,267. (*Mr. Balfour Browne.*) First, taking Teddington at high water, upon the 14th of September, I see the albumenoid ammonia in parts per 1,000,000 was ·120; is that about a fair average that you would expect from river water?—That is about what it should be at Teddington before the water is filtered, that is to say, filtered by the water companies.

12,268. I see in every case that has yet caught my eye, the proportion is higher for high water than for low water?—Yes, to a certain point it is.

12,269. Take St. Paul's Pier, the proportion is ·120 for low water, and ·180 for high water?—Yes.

12,270. As you come down, I see the amount of albumenoid ammonia increases; is that so?—Yes.

12,271. Until at North Woolwich you get at low water ·2, and at high water 1·04?—That is so; that was a very peculiar sample; it stunk immensely.

(*Mr. Bidder.*) That appears to have been an abnormal sample.

(*Witness.*) I think in all probability it was taken where the flow of the river coming round from North Woolwich would carry the sewage.

(*Mr. Bidder.*) There is a sewer discharging at North Woolwich; perhaps you are not aware of that.

12,272. (*Mr. Balfour Browne.*) Leaving out that specimen, there is a gradual rise to Barking, where you get ·26 and ·24. At Crossness it is still higher, and then it begins to decrease till you get to Southend?—Yes; all I would say about that is, that it is clear the influence of the sewage is found very strongly in the middle section of the river.

12,273. It shows that in the central section of the river there is more sewage than anywhere else?—Yes, in the central section of the river from North Woolwich perhaps to Erith, and I might say that the very reason why it falls off below is that there is a great deal more sea water there. The quantity of sewage in comparison to the sea water is so much less.

12,274. I see, with regard to the sample at North Woolwich, it could scarcely be taken opposite the sewer, because it was taken at three points across the river?—That is so.

12,275. Do you believe that the reduction of the sewage by means of oxidation would be considerable in this case?—It would not be practically considerable, but, of course, it would be considerable.

12,276. But not practically considerable to abate the nuisance you have spoken of?—I was quite surprised to hear it discussed as it was discussed, because the quantity of oxygen required is so enormous to get rid of a day's sewage. The solid matter in a day's sewage is something like 400 or 500 tons of total fæces, and it is a well known rule in chemistry that non-nitrogenous matter like sugar and gum, and things of that kind, take their own weight of oxygen to consume them, and that nitrogenous matters like gelatine, albumen, creatine, and so on, take double their weight of oxygen to destroy them.

12,277. (*Mr. Bidder.*) So that it would be something between those limits?—You may take the lesser one if you like.

(*Mr. Balfour Browne.*) You would want weight for weight of oxygen.

12,278. (*Mr. Bidder.*) You would want 100 tons of oxygen?—You would require a great deal more than that.

12,279. Of course, taking the dry matter only, it would be 100 or 110?—It would be 250 tons, including the dry matter, not only the fæces but the urine as well, that is in the liquid of the sewage, but it would be matter that would have to be oxidised.

12,280. One hundred tons solid from fæces, and 150 tons of solid matter from the liquid sewage?—Yes, that would be the lowest. I do not put it as an estimate of what comes from the sewer, but of what comes from the main. I say it would require its own weight of oxygen to destroy it.

12,281. (*Professor Williamson.*) The residue of the urine, so far as it consists of urea, would not require oxygen?—No, but I am not allowing for any other things; there is a great deal more in the sewage than that.

12,282. (*Chairman.*) What would require oxygen would be 100 tons of dry matter?—Say that 100 tons of oxygen were required, put it in the mildest fashion you will.

12,283. (*Mr. Balfour Browne.*) Could that practically be brought to bear upon the oxidation of this quantity of sewage?—I cannot see that it would, because it has to be dissolved, and then a fresh quantity to be brought to it, and in point of fact if oxygen were taken from the air to destroy the whole; if it were really the fact that the whole of the organic matter in a day's sewage were destroyed by the oxygen delivered to it by the air, the air in that neighbourhood would become absolutely without oxygen.

12,284. Does the 150 tons include the urea?—It does include the urea.

12,285. (*Chairman.*) But the urea would not require oxygen?—It would not.

12,286. (*Mr. Bidder.*) The urea, as you told us, being oxidised before it gets to the river, what would be the total solid matter at the time of discharge into the river?—The urea would be converted into carbonate of ammonia.

12,287. (*Professor Williamson.*) If you wrote off urea from the total solids what difference would that

*Prof. J. T. Way, F.C.S.*

14 March 1883.

make; can you give it us roughly?—The urea of the urine is not half the solid.

12,288. It is something about approaching to it, is it not.

12,289. (*Dr. Stevenson.*) Then there is the mineral matter in the urine, which is about one-fifth?—Yes, that is a good deal. I do not wish to overrate the matter. I will put it in this way: If I take the fæces alone, and say that 100 tons of oxygen are wanted, it is an enormous quantity to be obtained to bring to the surface of the river to be changed for something else; and my belief is that if it were possible that the whole of the sewage should be burnt up day by day as it went in, the air of the neighbourhood would be irrespirable; all the oxygen would be gone.

12,290. A remarkable reduction of oxygen in the water has been shown by Dr. Tidy and Professors Heaton and Tuson. I daresay you were here when they gave their evidence as to that,—what does that show to your mind; does that show the eating up of the sewage?—It shows the eating up of the oxygen, I think; there is such an enormous amount of organic material ready to be oxidised in the sewage, that it takes it in hand immediately and uses it, but where the next lot of oxygen is to come from it is not so easy to see.

12,291. (*Mr. Bidder.*) But it does indicate *pro tanto* that the sewage is being oxidised?—Yes, it does, and it shows a disposition in the sewage to be oxidised.

Adjourned to Tuesday the 10th of April at half-past 12.

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# House of Commons Committee Room, No. 25.

## THIRTY-FIRST DAY.

### Tuesday, 10th April 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
FRANCOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary.*

(*Mr. Lumley Smith.*) My Lord, at the conclusion of the last day we finished the evidence-in-chief of Professor Way, and now my learned friend, if he wishes it, has an opportunity of cross-examining him.

(*Mr. Norman Bazalgette.*) We have no questions to ask Professor Way.

(*Mr. Lumley Smith.*) The next point is this. There were various samples of water taken for the purpose of analysis, and my learned friends said that they did not desire us to call all the men who took the samples, but that they wished to have the men who took the samples at three places, viz., Erith, Gravesend, and Southend. I think my learned friend is anxious to know how long they took, and I propose now to call those witnesses.

WILLIAM HICKS examined.

*W. Hicks.*

10 April 1883.

12,292. (*Mr. Lumley Smith.*) I believe you are the keeper of the hospital ship "Rhin"?—Yes.

12,293. That belongs to the Port Sanitary Authority, I believe?—Yes.

12,294. Did you, upon the 14th September, take three samples of water?—Yes.

12,295. Do you remember how you labelled them?—Yes.

12,296. How were they labelled?—"North shore," "Middle Channel," and "South shore."

12,297. I believe you handed them to Dr. Collingridge?—Yes.

12,298. Upon the 22nd September you took three samples, did you not?—Yes.

12,299. Did you take them in the same places, as nearly as you could, as before?—Yes, in the same positions as the first.

12,300. Now, having settled that they were in the same positions on both days, I will ask you what were those positions; which did you take first?—I took that upon the south shore first.

12,301. Is there anything to fix the place where you took that sample?—I took it alongside of the ship, upon the south shore.

12,302. Your ship is anchored at Gravesend, is it not?—Yes.

12,303. And you took your first sample close to your ship?—Yes.

12,304. Could you tell us at all how far it is from the shore; of course, the shore would vary at high water and at low water?—I should say the mid-channel sample would be about half a mile from each shore. The first would be taken a quarter of a mile from the shore, the next a quarter of a mile from that to the mid-channel, and the next a quarter of a mile from the other shore.

12,305. That is how you took them?—Yes.

12,306. Did you take them at high water or at low water?—I took them at low water.

12,307. And at high also?—Yes.

12,308. Then you took six samples; is that so, if you took them at high and low water?—I took two off the south shore, four in the middle, and two off the north shore, that was eight bottles.

12,309. On each day?—On each day.

12,310. You took one how deep below the surface?—22 feet below the surface.

12,311. In each position, you took one sample one foot from the surface?—Yes.

12,312. And where you could get 20 feet you took 20 feet?—Yes.

Cross-examined by Mr. NORMAN BAZALGETTE.

12,313. You have not told us at what part of the river you took these samples; were they taken at Erith, Gravesend, or Southend?—They were nearer Gravesend. I am only lying one mile below Gravesend.

12,314. What was it that determined in your mind

the exact time when high water or low water was reached when you took the samples?—According to my orders.

12,315. How did you know it was high water when you took the samples?—Because the ship swings at the ebb and swings at the flood, that is the reason why I knew it.

12,316. You determined it by the swinging of the ship?—Yes.

12,317. You say you took two off the south shore, and two off the north shore, and four in mid-channel?—Yes.

12,318. Why did you take four in mid-channel and only two at the sides?—Because I was ordered.

12,319. How long did it take you to take all those samples?—I should say 20 minutes.

12,320. What is the width of the river at Gravesend?—I should say a mile and a half.

12,321. First of all, off the south shore you took a sample from the surface, and then you took a sample 20 feet deep?—Yes.

12,322. Then you took another off the south shore and then went to the middle of the channel?—No, I went to the south side of the river, and then I went to mid-channel, and then I went to the north shore, and that finished it.

12,323. First you took a sample upon the surface, and then another 20 feet deep at the three places?—Yes.

12,324. Did it only take you 20 minutes to take all those samples?—From 20 to 30 minutes; I had not any watch to go by.

12,325. When you took your 20 feet sample, what precaution did you take to secure that the water you took represented the water at 20 feet deep?—I do not think anybody could do it better than I could.

12,326. But will you show us how you did it?—If you will give me a bottle, I could do it, I could not do it without; the stopper was pu into the bottle, and the bottle was put into a bag with a weight upon it, and the bottle was lowered to 20 feet or whatever it might be; and then, when the bottle was down there, the piece of line was hauled in, and the stopper went out of the bottle, and the bottle was filled with the water, which was at 20 feet; if I had filled the bottle before it got down, it would not have been a true sample of the water.

12,327. Then you have got a sample of water taken at 22 feet, how did you get that up?—I hauled it up. I hauled the bag back.

12,328. Did you put back the stopper before you hauled it up?—No.

12,329. (*Chairman.*) What sort of bottle was it, was it a wine bottle, a bottle with a small neck, or what?—It was a bottle with a small neck for the size, I should say.

12,330. (*Mr. Norman Bazalgette.*) At low water, did you take your samples, 20 feet deep?—Yes.

12,331. At both north shore, south shore, and mid-channel?—Yes.

12,332. Did you touch the bottom?—No, I did not touch the bottom because my ship draws 17 feet of water.

12,333. Did you take any soundings to find out what the depth of the water was at low water?—No, only that I dipped in the line that the bottle was fast to.

Re-examined by Mr. Lumley Smith.

12,334. You had a line, and you lowered that line to the bottom?—Yes.

12,335. And then you lowered the bottle and then you drew the stopper, and then you drew out the bottle with the water in it?—Yes.

12,336. (*Mr. Norman Bazalgette.*) You say that the whole operation occupied from 20 to 30 minutes?—Yes.

12,237. Do you say that from observation by your watch, or was it only a rough guess?—It was only a rough calculation.

The witness withdrew.

Walter Bound examined.



12,338. (*Mr. Lumley Smith.*) What are you?—Pier master.

12,339. At Erith?—Yes.

12,340. Did you take some samples of water at Erith?—I did.

12,341. On what days did you take them; did you take them upon the 14th September?—I did.

12,342. In how many different places did you take them?—I took them in four different places across the river.

12,343. Did you take them at high water and at low water, or only at one state of the tide?—At high water and low water too.

12,344. Could you tell us the position in the river in which you took them?—I took them in a line from the corner of the pier to the Red House on the north shore.

12,345. Could you tell us the distances at which you took them from the shore?—I could not tell you the exact distances across the river, but I divided the distance across the river as nearly as I could into equal parts.

12,346. What did you do with the samples; did you come back with each sample or bring them back together?—I had all my bottles ready in the boat, and took them as I went.

12,347. When you got the samples did you cork them?—I corked them and labelled them.

12,348. Were your bottles full?—They were full bottles.

12,349. What did you do with them?—I brought them to the pier house ready for the gentlemen to come and take them away.

12,350. How long did it take you from first to last to take the whole of the samples?—I think I might have been a little more than half-an-hour taking them right across.

12,351. And you corked them up together?—Yes.

12,352. You took some more samples upon the 30th November, did you not?—I did.

12,353. Did you do those in the same way?—You mean the small samples?

12,354. Yes?—I took some small samples off the end of the pier.

12,355. I do not think that any question arises about them, but you took some small samples off the end of the pier every day from October 10th?—Yes.

12,356. How did you get your deep samples?—I had a line fixed to a lead and a line fixed to the stopper, and I had the line marked to 20 feet, and when it was down to 20 feet, I drew the stopper, and no water could go in then in drawing it up, because the bottle was full.

Cross-examined by Mr. Norman Bazalgette.

12,357. Your observations took you a little over half-an-hour to make one set?—It might be three-quarters of an hour. I had no watch in my pocket to measure it by.

*W. Bound.*

10 April 1883.

12,358. How many samples did you take then?—took two at each place.

12,359. That was 8 samples; one set 20 feet deep and one just below the surface?—Yes.

12,360. At the 20 feet deep one did you get on to the mud?—No.

12,361. Do you know what depth you get on the north shore or upon the south shore at Erith at low water?—I do not know exactly; it is a thing I do not profess to know.

Re-examined by Mr. LUMLEY SMITH.

12,362. Did you go at low water to the same places as you did at high water, or did you divide the river in the same way?—I took the same places as near as I could.

The witness withdrew.

WILLIAM BRADLEY examined.

*W. Bradley.*

12,363. (*Mr. Lumley Smith.*) What are you?—A lighthouse keeper.

12,364. At the pier head at Southend?—Yes.

12,365. Did you take some samples of water by direction of the Port Sanitary Authority upon three days?—Yes.

12,366. On September 14th, September 22nd, and November 30th?—Yes.

12,367. Did you take the samples both at high water and at low water?—Yes, at high and low water.

12,368. Upon each occasion how many samples did you take?—I took them every half mile for two miles from the pier-head. Upon the third occasion, 30th November 1882, I only took the samples off the pier head.

12,369. At how many points across the river did you take them?—Four of them.

12,370. How far from the pier-head was the first?—Half-a-mile.

12,371. Then a mile?—Yes, then a mile and a half and two miles.

12,372. How many did you take at each place?—One 20 feet below the surface, and one one foot below the surface.

12,373. Will you just tell us how you took the deep ones?—I made the bottle fast to the lead line and lowered it down, and made the cork fast to a piece of string, and then pulled the cork out.

12,374. And then drew it up?—I let it remain two or three minutes.

12,375. Did you cork them?—Yes, after they were up.

12,376. What did you mean by letting it remain two or three minutes; do you mean before you pulled it up?—Yes.

12,377. And as soon as you got the bottles up, you corked them up and labelled them?—Yes.

12,378. How long did it take you to take each set. I believe the river is pretty wide there; did you go straight across?—I suppose it took rather more than half-an-hour.

12,379. Is that half-an-hour to go across and come back?—Half-an-hour to go there and half-an-hour back again.

12,380. It would take about an hour altogether?—Yes.

Cross-examined by Mr. NORMAN BAZALGETTE.

12,381. You say you began at the pier-head and took them at four stations till you reached two miles?—Yes.

12,382. That would be about the centre of the river?—It would be about the centre from the pier-head to the Nore Sand.

12,383. Did you take any upon the other side of the river at all?—No, not upon the other side of the river.

The witness withdrew.

*Mr. Lumley Smith* stated that he was desirous of calling one witness who was in the habit of raising wrecks.

Mr. CHARLES WOOD examined.

*Mr. C. Wood.*

12,384. (*Mr. Lumley Smith.*) You are superintendent of the wreck and mooring service of the Thames Conservancy?—Yes.

12,385. How long have you been in the service of the Thames Conservancy?—Since 1869.

12,386. Have you been during that time engaged in lifting wrecks in the River Thames?—Yes.

12,387. Previously to being in their service, had you any experience in lifting wrecks?—Yes.

12,388. For how long altogether?—For about 20 years before I was in their service.

12,389. That makes altogether between 30 and 40 years' experience in raising wrecks in the Thames?—Yes.

12,390. Have you in the course of that time found much difference in the condition of the wrecks which have been raised?—Yes.

12,391. In what respects have you found a difference?—I have found a great quantity of mud in the bed of the river.

12,392. To make a little comparison, do you remember raising a wreck in Halfway Reach about 1860 or 1861?—Yes, I do.

12,393. Whereabouts was it in Halfway Reach?—She was just by Dagenham, above where the Dagenham Docks were to be.

12,394. You raised her and put her upon the foreshore off Dagenham?—Yes, off Dagenham.

12,395. Had she been down long?—She had been down about a week.

12,396. In what condition did she come up?—She had a small trifle of mud in her, but not a great deal.

12,397. Where did you put her?—I put her upon the foreshore about half-a-mile above Dagenham Dock.

12,398. What state was the ground in there?—It was perfectly clean—a hard shingle.

12,399. Were you able to walk round her and repair her?—Yes.

12,400. Do you remember another vessel being sunk in the same spot?—Yes, as nearly as possible.

12,401. When was that?—In November last.

12,402. That would be about 20 years afterwards?—Yes.

12,403. Was she sunk about the same spot?—She had been in collision, and they ran her upon the shore, and there was nine feet of mud; the mud was up to her marks nine feet.

12,404. Was that upon the same spot as you had found the wreck in 1861?—Yes.

12,405. (*Chairman.*) What was the mud in the first vessel was it mud that got in from where she

lay, or mud that flowed into her from the water?—Mud that flowed into her from settlement.

12,406. (*Mr. Lumley Smith.*) You say that where you found a clean beach upon the first occasion you found nine feet of mud upon the second?—Yes.

12,407. What sort of mud was it?—It was rather white upon the top, but underneath it was black mud—all sewage.

(*Chairman.*) This evidence appears to relate, not so much to mud depositing inside the vessel, as to mud existing upon the bank.

12,408. (*Mr. Lumley Smith to the witness.*) That is true. Last month were you engaged to raise a couple of barges?—Yes, I was.

12,409. Where were they?—At Northfleet Hope.

12,410. Where?—One was in mid channel, and the other more to the southward.

12,411. How long had those barges been in the water?—One a week, and the other about five days.

12,412. What state did they come up in?—They had a great quantity of mud in them.

12,413. Was it more or less than in the barge that you raised in 1860 or 1861?—Yes, much more.

12,414. What sort of mud was that?—What was in the barges was loose white mud, settlement—it had not been down long enough to get like the other.

12,415. Is there much mud in Northfleet Hope?—Yes.

12,416. What sort of mud is it?—Black mud.

12,417. Is it like ordinary Thames mud or not?—No, it smells and is very black; it came up upon our chains—as we hove the chains under the wreck the chains were smothered with it.

12,418. Is that the same sort of mud as you find in Halfway Reach now?—Yes.

12,419. Do you know Gravesend Reach?—Yes, I do. *Mr. C. Wood.* 10 April 1883.

12,420. Have you found mud there in deep water?—Yes, black mud.

12,421. The same as you have been describing?—Yes.

12,422. Do you remember in bygone years when there used to be that sort of mud there?—No.

12,423. What sort of bottom used there to be?—Clay bottom in some parts, and some parts were gravel.

12,424. At any rate there was none of this black mud?—There was none of this black mud.

12,425. Do you remember the sewer outfalls being opened in 1864, and the sewage being brought down here?—Yes.

12,426. Now as to the water above Greenwich, is it better or worse than it used to be?—I think that the water is brighter, and that there is less mud above Greenwich than there used to be.

12,427. As to the water below, is that worse or better?—It is much worse.

12,428. What part of the water is worse in consequence, in your opinion, of the discharge of the sewage?—Right away from Woolwich to Sea Reach.

12,429. All that you think is worse than it was before?—Yes, much worse.

12,430. What is the worst point of all?—Gravesend Reach and Lower Hope are very bad, and at Jenning Tree Point the bottom has grown up 10 feet within the last few years.

12,431. What sort of mud is that?—All sorts: sponges and rags and guts, and all sorts of things; you might load a ship with sponges and rags down there, if you liked.

Cross-examined by Mr. Norman Bazalgette.

12,432. You have been raising vessels for the Thames Conservancy since 1869?—Yes.

12,433. Who were you raising them for before 1869?—Anybody I could get to employ me.

12,434. You say that in 1861, when you raised a vessel in Halfway Reach, there was a small quantity of mud in her which was not objectionable?—Yes.

12,435. And that last November you raised a steamer and found about nine feet of mud where before you found none?—Yes.

12,436. Did I hear you describe that mud as being clean enough upon the top, but dirty when you got inside it?—It is clean enough upon the top, but when you come to go into it, it is all black sewage.

12,437. It is not objectionable upon the surface?—It is not upon the surface.

12,438. You say that the barges you raised last month had a quantity of white mud upon them, what kind of white mud was that—clay?—No, it was ordinary white mud.

Re-examined by Mr. Lumley Smith.

12,439. There has been a great quantity of land water coming down of late years, has there not?—Yes, a great quantity.

Examined by the Commission.

12,440. (*Chairman.*) You have known the river for a long time, have you not?—I have.

12,441. I suppose you always have known mud in it that you could not walk upon?—Yes.

12,442. What is the greatest depth of natural mud that you have known the Thames produce?—There used to be mud in the Upper Pool.

12,443. What depth?—Three or four feet deep, perhaps.

12,444. Not eight or nine feet?—No.

12,445. Has that mud in the Upper Pool got washed away now?—Yes.

12,446. To what do you attribute that, to the washing of the steamers?—No; I think there has been a good deal of land water down of late years.

12,447. You think it will come again in all probability?—Yes, I daresay it will.

12,448. Was it there a year or two years ago?—No, it has been lessening for some years.

12,449. It was a different mud, you say, from this black mud you have spoken of?—Yes, it was not such a black mud.

The witness withdrew.

George Custance examined.

12,450. (*Mr. Lumley Smith.*) Were you at one time pier master at Erith?—Yes. *G. Custance.*

12,451. From when to when?—I ceased to be so in October 1881, I think.

12,452. You were pier master there till two years ago?—Yes.

12,453. How long were you there as pier master?—About 19 years.

12,454. How old are you?—I am about 65.

12,455. You know pretty well, do you not, what the river has been like at Erith?—Yes.

12,456. Will you tell me this, do you remember the outfalls being opened at Barking and Crossness?—I remember the first outfall, that was at Crossness, before Barking.

12,457. You are not quite right there I think, because Barking was opened first?—No, I say not.

12,458. Before the outfalls were opened what was

*G. Custance.*
10 April 1883.

the river like at Erith?—It was very good, it was beautiful water, clear and wholesome and healthy.

12,459. What used they to use it for?—I have known the water to be made use of at Woolwich for drinking water before I came to Erith.

12,460. Did you use it for cleaning purposes at Erith?—We used to do so before the outfalls were opened.

12,461. When you were last at Erith, what condition did you find the river in?—It was very bad.

*The Chairman* intimated that these facts were to a certain extent conceded by the other side.

12,462. (*Mr. Lumley Smith.*) Can you use the water for cleaning now?—You must take it at a certain time of the tide if you want to use it for cleaning purposes, such as cleaning yachts; the water is not fit at half ebb for cleaning decks and scouring; instead of making them white, it makes them rather dirty.

12,463. Have you had to complain of the smell of the river?—Yes, very much.

12,464. Does it affect your health and comfort?—It has affected me myself several times.

12,465. To what extent has it affected you?—It has given me great headache and diarrhœa.

12,466. Did you attribute that to the river?—I did.

12,467. Was the smell of the river at this time disagreeable when you were ill?—It was. I attributed my illness always to that.

12,468. Amongst your men have you known it to produce illness?—I have known it to produce headache and stomach-ache, and I have had medicines given to me to distribute which would be good for that.

12,469. How would that be perceptible?—In the vapour and smell that would arise from the mud. When gentlemen would come to land upon the pier, they would turn back again and say it was not fit to smell, that they could not stand it.

Cross-examined by Mr. Norman Bazalgette.

12,470. By the side of the pier at Erith one of the sewers runs out, does it not?—But that is nothing that goes out a long distance away from the pier, it was from the old garden, but it is taken about 300 or 400 feet below low water mark; that does not affect it, it is not from that at all.

12,471. Do you happen to have noticed whether that sewer is in a broken and imperfect state?—Some barge might have sat upon the pipe, perhaps.

12,472. But have you noticed that it is imperfect in its condition?—No.

12,473. You have stated that you suffered from illness from being over the river?—Yes, lots of times.

12,474. When; at what time of the year?—In the summer, many times off and on, mostly when I have been cleaning upon the pier.

12,475. Did you have to knock off work, to stay off from your work?—At times I would have, but not for weeks, only a day or so.

12,476. What has been the longest period that you had to stay away?—About two or three days.

12,477. And did you put yourself under the doctor's hands?—Yes, I have done so, but my wife used to get me some stuff to take upon sugar, or I would take some ginger brandy to ease myself; but I never staid regularly away from my work.

12,478. You say the water has not been drunk at Woolwich for many years?—It has not.

12,479. Would you tell me how long it has ceased to be drunk at Woolwich?—I could not tell you; but when I was in the Steam Reserve at Woolwich I made use of it daily.

12,480. How long ago would that be?—In 1847.

12,481. Do you happen to know the flushing reservoir at Erith where the water is admitted at high tide, and then let out with the ebb to wash away the mud?—At what part of Erith?

12,482. In the timber yards there, do you know them?—Mr. Beadel's, do you mean?

12,483. Above the pier?—There is only a coal wharf and a causeway there; there is no letting out of water there.

12,484. You do not know of any reservoirs of that description for washing away the mud?—There is one there which washes out the mud from Mr. Beadel's coal wharf.

12,485. Has that been at Erith for a good many years?—Yes.

12,486. So that there has always been a tendency for the mud to deposit there?—No, not for the mud to deposit there; but to keep the mud from accumulating from the outfall, they have had to get the reservoir made larger to wash the mud away.

12,487. But it existed before?—Yes, it existed before, but it was a small one before.

Re-examined by Mr. Lumley Smith.

12,488. It was a small one before, but they have had to make it larger?—Yes, and since they have had steamboats coming there, they have had it made larger to keep the channel clear for steamboats.

Examined by the Commission.

12,489. (*Chairman.*) There was a time, you say, when you used to drink the Thames water at Woolwich?—Yes.

12,490. You do not remember when you left off doing so, but do you remember whether it was before the outfalls were there, and did you continue up to the time of the outfalls to drink the water, or did you discontinue it before that?—Yes, before that; because the Government had means at the dockyard of supplying the ships with water.

12,491. So that you have no occasion to use it?—No.

12,492. Can you say that the water was fit for use to drink up to the time of the outfalls?—Yes, up to the time of the outfalls, but after that it was not fit for drinking purposes.

12,493. How do you know it was fit for use up to the time of the outfalls?—By drinking it.

12,494. But did you drink it?—We did drink it before the outfalls, but afterwards, when the outfalls were opened, as the Government had brought us the pure water, who would drink the dirty water?

The witness withdrew.

*Mr. Lumley Smith* stated that that concluded the case on behalf of the Corporation.

(*Chairman to Mr. Bidder.*) The merest sketch of your case is all we require.

(*Mr. Bidder.*) That is my own idea, my Lord, I had it in my mind to make that observation to the Commission that what you will probably expect from me now is not a detailed analysis of the evidence which has been given, but rather a general outline of the aspect of the case which the Metropolitan Board

of Works desire to put before the Commission, and I hope that I shall be able to do that within a very reasonable compass of time.

Now I begin naturally by turning to the Commission itself, and I see that the duty which is entrusted to your Lordship and to the other members of the Commission is "to enquire into the system under which "the drainage of the Metropolis is discharged into "the river and ascertain whether any evil effects "result therefrom, and whether any means can be "applied for remedying it;" and I suppose that that must be read and understood with reference to the surrounding circumstances. I cannot imagine, seeing that the actual discharge of the sewage of London into the River Thames is a fact, is a thing which is done with the knowledge and deliberate sanction of Parliament, I cannot imagine, I say, that this distinguished Commission is appointed for the purpose of discovering whether there is sewage in the river at that part, and it must be, I take it, that the object of the Commission is not to discover whether there are any things that a sentimentalist or a person of extremely delicate organization might consider objectionable if he happened to go into the neighbourhood; but whether there is any real or substantial grievance, whether, in point of fact, the discharge of the sewage at Barking and Crossness does cause substantial injury to health, or inconvenience to those who are resident in that district. I think you cannot shut out of consideration that which was the former condition of the river, because we know that at the time when the Metropolitan Main Drainage outfalls were sanctioned the condition of the River Thames had been, as everybody knows, growing worse and worse, and it is not to be forgotten that that which was sanctioned and has been done under the powers of the Act of 1858 was sanctioned and done for the purpose of getting rid of what had become a very intolerable state of things in the river Thames, both here and all the way down to Barking, and even below.

At that time we had abundant evidence, I am not going to trouble you with it in detail now, that at that time, not only in the upper reaches of the river, but in the lower reaches of the river, the condition of the river Thames was very bad indeed. You have had several witnesses examined here, and I cannot help saying that some of the evidence called by my learned friend, Mr. Beaumont Morice, seems to me to be very much exaggerated, and although you have had some gentlemen who have told you that at that time the river was perfectly clear in the lower part of it, and that its bed was of a sandy and clean character, yet you have had other witnesses produced by my learned friend who tell you the reverse, and who tell you that which we know to be the fact, namely, the mud of the Thames was always an offensive and unpleasant product, and that the condition of the Thames was very bad before the outfalls were created; and I say, as the first observation to be made in considering the question as regards the evil effects of the discharge of the sewage under the present system, that you cannot shut out from your minds what was the state of things that existed before that system was brought into operation, not merely up here, but specially at the part which is said to be affected by it.

Now the first objection or hostile criticism against us made by the witnesses called on behalf of the City is this. On the part of Mr. Baldwin Latham a great deal of ingenuity has been expended in endeavouring to show that the system of sewerage is entirely inadequate, arguing from what was contemplated in 1855, and arguing from the Report of that date. The argument is, the system of sewers must be inadequate because it is clear that you then only provided for a certain population, whereas the population now exceeds that provided for. I confess that seems to me entirely beside the mark, because, whether we intended to provide for 3,000,000 or 4,000,000, or any other number, the question is whether, the sewers being what they are, there are the evil effects which some people say there are. But if it is necessary to go further in answer to Mr. Baldwin Latham, you will hear from Sir Joseph Bazalgette that Mr. Baldwin Latham is entirely mistaken, and that, although he does find certain figures of population in that Report, yet, in point of fact, those calculations of the capacity of the sewers were made upon hypotheses (which have turned out to be incorrect) which were very adverse to the capacity of the sewers—that is to say, it was assumed at that time that such was the inequality of flow at different periods of the day that the sewers had, within a limited number of hours, within 6 hours, to cope with half the sewage of the whole 24 hours, and it was upon a hypothesis of that kind that the sewers were assumed to be capable of dealing with a certain population. Experience has shown that that hypothesis is not realised, but that, owing to the varying distances of the population from the outfall, which necessarily equalises the flow, the result is that, instead of having to deal with half the sewage in six hours, you have to deal with it in eight or nine hours, and that consequently the capacity of the sewers is proportionately increased, but, nevertheless, I think it is only necessary to show what is the actual capacity of the sewers.

Now another point has been made which again, I say, seems to me to be beside the mark; and I must say that I think my learned friend's scientific witnesses have been very hard put to it to support the allegation they have made, or they would not have cast about so much for irrelevant matter, but they said this, when you got this system sanctioned it was contemplated that you would deodorize the sewage, use lime or deodorize it in some other way, but you did not deodorize it, and therefore you ought not to shelter yourselves under the plea that this is a thing sanctioned by Parliament. Now I looked last night at the Act of 1858, and what do I find with regard to deodorization there? That the deodorization then contemplated was a temporary expedient until the works were completed. I have here the 23rd section of the Act of 1858, and you shall judge for yourselves; it says: "The Metropolitan Board of Works in the "meantime, and until the works required by this "Act for the purification of the river Thames are "completed, may do all such works and apply all "such means as they may deem proper for deodorizing "such sewage, or otherwise protecting the public "health from any injurious consequences therefrom, "and may defray the expenses," and so on; and then the next clause goes on to say, "The said Metro-"politan Board shall cause all works to be executed "under this Act to be constructed and kept so as "not to be a nuisance, and shall, in deodorizing any "sewage, and in disposing of any sewage or refuse "from sewers, act in such manner as not to create a "nuisance." Clearly, therefore, upon the face of the Act, as I venture to think, that deodorization was a temporary expedient. Again, I say, that is a matter beside the mark because, whether deodorization was or was not contemplated at that time, you have again to take the thing as it is, and see whether that is a nuisance. Sir Joseph Bazalgette will tell you that upon certain occasions deodorization was tried for certain purposes, and it was abandoned, because, in point of fact, deodorization was a greater nuisance by far than the sewage.

(*Sir John Coode.*) Was that so since the completion of the system?

(*Mr. Bidder.*) I find I have misled the Commission; it was not that it was tried at Barking and Crossness, but that it was tried at Leicester, and experience there showed that the large quantities of matter to be dealt with created a greater nuisance than the sewage itself; and when it was seen that in the case of London the quantities would be still greater, it was out of the question. I apologise for misunderstanding, and therefore misrepresenting, Sir Joseph Bazalgette; it was not tried at Crossness.

Now, putting aside those which I venture to say are irrelevant charges, and coming to the system as it was sanctioned and as it was carried out, I wish to make this further observation—I have already reminded you of the then condition of the river. There is another very simple "platitude," perhaps, if you please, which

10 April 1883.

existed in 1858, and exists now, and that is this—you had as a great fact the sewage of London, you could not annihilate that sewage, you had to do something with it, and I think I am entitled to speak of the experience of 1858, and of the present time, that no known method of deodorization or of sewage irrigation could be applied to the sewage of such a gigantic population as that of London; and consequently you had to discharge that sewage into water, the Thames or the sea; somewhere. It is a fact that you cannot escape from, and the particular places which were selected, Barking and Crossness, were selected, after long consideration, after great discussion, after the opinions of many eminent engineers had been given upon them, as being the spots most favourably situated, for many reasons, within any reasonable distance of London. In point of fact, just as one finds, in cases of objectionable manufactures, tanneries, and chemical and other manufactories, that they resort to places which are, as it were, allocated to purposes of that kind, so it was done in the case of Barking and Crossness; you have there a length of something like five or six miles of river, which are, I may say, dedicated to stinks, where there is no house or residential property of any kind whatever along the margin of the river, but which is exclusively occupied by various kinds of manufactories of the most offensive character, all of them producing divers very offensive, and, as I should say, injurious smells. You have artificial manure works; you have guano works and you have candle works; and when you go, as some of the Commissioners have done, and, as I hope, your Lordship will do, down that part of the river, you will have a selection of horrible smells such as perhaps you have not encountered for many years past, and, beyond doubt, that is one reason why those two places were selected. It has been pointed out, and is a fact, that further up the river it is one continuous population; but you cannot go lower down, until you get beyond Gravesend, to find any place that is comparable to that for its freedom from any possibility of being injuriously affected, and its suitability for businesses of an offensive and unpleasant character. I cannot help thinking that that must be borne in mind, because I can well understand that your Lordship might hold that that which was regarded as a nuisance in Belgravia would not be held to be a nuisance in Bermondsey. There no doubt may be times when people who choose to lay their boats within a short distance of the outfall may smell an unsavoury smell; all that has to be weighed in consideration with the fact that the neighbourhood is one specially selected for that very reason. I am not coming here upon the part of the Metropolitan Board of Works to suggest to the Commission that the sewage of three and a half millions of people is put into the Thames at these two parts, and produces no perceptible effects whatever. I suppose nobody ever expected that such a thing could happen, that 26,000,000 cubic feet of sewage could be poured into the river every day and leave no sign of its presence. Parliament must have contemplated that there would be certain signs and effects locally produced by the inpouring of the sewage, but surely it is not that which you are appointed to discover, and what I venture to describe as the point in this case is the distinction between the immediate and local effect of pouring in the sewage and the general riverine effects. I think the two things should be distinguished. I admit that when the sewage is being discharged from the Barking or Crossness outfall, if you take a boat and go within 50 or 60 yards of this great volume of sewage which is pouring out, you will smell a very unsavoury smell, and see a very unsavoury sight, and for a distance of a quarter of a mile down the river you will be able to see a distinctly marked black line showing the boundary between the sewage flow and the general water of the Thames; that is what I speak of as the local and immediate effect of the inpouring of the sewage, that is, an effect which must have been contemplated, and which must necessarily follow wherever you put it. If you went 15 miles below Gravesend, if you went to Southend, if you went to the sea, it is an effect which would equally be caused wherever you discharged; you cannot go anywhere where, by some magical transformation, the instant the sewage gets into the water or the sea, it shall be instantaneously annihilated, it is a process of time anywhere, and wherever you pour into the river or the sea the sewage, you must have at that spot signs of its presence, both to the sight and the smell; it must be perceptible for a time. But while I admit that such indications must and do follow in the case of the outfalls at Crossness and Barking, I say, as regards the general effect upon the Thames, the suggestion that its pollution is dangerous and deleterious to the health of the riverine districts is entirely unfounded; and when I come carefully to analyse the evidence, I shall show that it is entirely contrary to the fact. I cannot help reminding the Commission of this, that although you are by no means bound by what has been done before, yet already this matter has been threshed out twice over and very carefully; for first, as far back as the year 1869, the people of Barking made complaints, and Mr. Rawlinson was sent down to inquire, and your Lordship may remember that, having inquired and taken a vast amount of evidence, he came to certain conclusions, one of which perhaps will be sufficient if I mention, that "the memorialists "are not in a position to establish deterioration of "health by emanation from the Metropolitan main "sewerage outfall works, as the town of Barking is "without local government powers and contains many "cesspools and much sewage-polluted subsoil."

(*Chairman.*) I think we have had a witness from Barking to show a nuisance there.

(*Mr. Bidder.*) No; with the exception of a policeman whose beat lies along the margin of the river, and who sees the line of the sewage upon the river when the tide is flowing down, there is nobody from the neighbourhood of Barking. Then I must remind you of the inquiry of 1879. I know what will be said upon the other side. They will say, "that is at the "instance of the Conservators of the Thames, and is "simply directed to the fact whether you were "obstructing the navigation; it by no means follows "that because the arbitrators upon that inquiry found "as they did, and unanimously, that there was no case "made out, you are not thereby tainting and polluting "the water." Of course I conceive that, but you will see what a large bearing that had upon this inquiry, how large a portion of the ground now covered was covered upon that inquiry; because you have had before you a great number of witnesses, and the only witnesses who attempt to prove the fact of nuisance are those called by my learned friend Mr. Morice, viz., people in the neighbourhood of Erith. The sum and substance of their evidence is that Erith was once a beautiful bay with a bright sandy shore, and now, since your outfall, it is a nasty black fœtid shore with a continually increasing amount of fœtid mud, which is very injurious to the health of the town of Erith, and which is all sewage, which, in fact, is so identified with sewage that they do not call it mud, but call it sewage. Exactly the same case was made, as a matter of fact, by the Thames Conservators; they did not fight their battle upon that part of the field, but they took the banks which were more immediately in the neighbourhood of the outfall; they took the Crossness bank; they took the bank which is opposite the Barking outfall at Margaretness, and another two banks, and said the same thing. "Those banks never were there till your outfall was "opened, and they have grown foot by foot, the mud "of which is *post hoc*, and therefore *propter hoc*, "distinctly traceable to your sewage works." We met them there, and our answer to them now is exactly the same as it was in the case of the banks. Just as in that case, we proved to absolute demonstration that the causes of those banks were the works of the Conservators and others interested in the channel, and not the operation of the Board; and not only that, but we also took the mud of that which they called

the sewage, and we showed conclusively by actual analysis that it differed in no way from the ordinary Thames mud to be found everywhere up and down the River Thames; so we shall meet them here. Your Lordship will see, therefore, that I am justified in saying how large a portion of the ground is covered by that inquiry. But I pass from that for the present, because I shall have a word or two to say about it immediately.

But while I admit, as I said a few minutes ago, the local and immediate effect of the sewage, I think this will come out, and I think it will surprise your Lordship, after all you have heard, especially when you have gone to see it for yourself, how rapidly the perceptible presence of the sewage is lost; it certainly struck myself, and I think it has struck everybody who has seen it belching out of these great sewer outfalls, as a nasty offensive stream which you trace keeping itself distinct by a black line from the rest of the river which flows with the tide,—I say it is remarkable how rapidly, after a few hundred yards, it fans out and disappears to the sight, and disappears to any ordinary sense from the general body of the river. That, of course, is a mere matter of general observation, but, beyond that, it will be the case of the Board to show you that that which seems to be true according to the eye and the nose is true also according to the analysis of the chemist, and true also according to the analysis of the microscopist, and true also in every way in which you can test it. The Erith people gave you a certain amount of evidence which, without analysing it in detail now, I think I can roughly classify under three heads; they said there were no fish; there used to be fish, such as whitebait, and now they are all gone, driven down the river; that is the effect of the poison of the sewage; and they said there were these large accumulations of fœtid mud, and that there were certain occasions upon which the water smelt offensively.

Now what is the answer of the Metropolitan Board of Works: first, about the fish; you will remember I conceded the fact that the fish to a great extent had disappeared, that where the fish had been plentiful in the neighbourhood of the outfalls they were rare; and then his Lordship suggested that I admitted the poisoning, while I repudiated the poisoning; and you seemed to think there was a sort of paradox in it. The answer is a very simple one,—the fish have disappeared, and disappeared in consequence of the sewage, but not because they are poisoned by sewage, but because the sewage in its oxidation has consumed the oxygen which they require for their life; and the very fact of the fish disappearing, while there is evidence that there is sewage in the river, and that it is being burnt up, is evidence also that there is oxygen in the river doing its work in burning up that sewage. And you have only to take the analysis of Dr. Tidy to show you one of the most pregnant facts of the case. As his figures show, the water which comes over Teddington Weir charged with its normal quantity of oxygen, a little less than two cubic inches to the gallon, as it gets down and approaches the outfalls, appears gradually to part with some of its oxygen, and when it gets into the neighbourhood of the outfalls in the neighbourhood of Erith it parts with the greater part of its oxygen, in fact, three fourths of its oxygen is gone. So that, whereas perhaps you have two inches of oxygen at Teddington Weir, when the water has flowed past Crossness and Barking, and has received its contribution of the sewage of the day, it arrives at Erith with more than three parts of its oxygen gone. It is perfectly intelligible why an air-breathing animal which depends upon the oxygen of the water for its life no longer affects that part of the river, nor can do so; but that very fact shows you that the river is doing its work in destroying the sewage, because the work of the destruction of the sewage is not this: it is not that the river is a mere scavenger to remove the sewage to a place where it will not be offensive, but it is more, it is burning it up by the oxygen of the water, so that that very fact of the driving down of the fish is a consequence and a necessary consequence and an indication of what is taking place in the Thames with regard to the destruction of the sewage. And beyond that, it being evident by the analyses of the chemists that that destruction is going on, the question follows: Is the river adequate to the work of destruction? The diminution of oxygen shows that the sewage is eating up the oxygen of the river. Is there evidence to show that there is oxygen enough to destroy the sewage? I shall show conclusively that there is.

But again, in order to keep my observations upon some system, let me now say a word or two about the other charges of the Erith people. I will refer to the mud question. Our answer is precisely the same to the Erith gentlemen as it was in the case of the other banks; an answer which amounted to demonstration there, and will here. First of all, the question whether in any part of the river mud deposits is a question purely of the set and the velocity of the water and the eddies and streams in that neighbourhood; you may put what you like into the River Thames, or any other place: sewage, pure sand, or pure silt; if you have a current running straight through it for three or four miles, of course you will not get a deposit; but if you alter the current of your river so that that which formerly received the scour of the current becomes a sort of lie-by or eddy, then you get stagnant water, and whatever there is in the river will be the thing that will be deposited. So that your Lordship sees, if I make myself clear, that the fact of the deposit has nothing to do with whether it is sewage or sand in the river. The fact of the deposit depends upon the flow of the currents; that which is in the river will deposit, or not, according to those conditions.

Now what is the cause of these deposits? Why, simply, that as in the previous case we showed what it was, so here, that, during or preceding the period of this deposit certain dredging operations have been taking place on the other side of the river which have improved it and deepened it, so that the main traffic of the river has been drawn the other side, and left this as stagnant water. Consequently, you have Erith left in a sort of eddy, and you have deposit begun and going on; and the sections, I think, will satisfy you that, in point of fact, the river has not been diminished, but the reverse, that the river channel is larger and better than before.

But that is not all my answer to the question. I say, I take the mud which you are pleased to call sewage, and to say it is black and nasty, but I take the mud and show you that, except in cases where it has come out of your own sewers, it is not different from the Thames mud all up and down the river. I take the mud and analyse it, and satisfy you that it has exactly the same constitution as Thames mud whether you take it up or below; whether you take it up at Westminster or down at Sea Reach. And not only that; I show you that, not only chemically, but microscopically, and I venture to say that I shall prove to demonstration to you, before I have done, that that mud is nothing more than ordinary Thames mud, and that, if you are to accept that mud as the produce of our outfalls, you have to account for a quantity of mud in the Thames which is 50 or 60 times the quantity of solid matter which ever came out of the outfalls since they have been constructed.

Now I do not deny that there may be a few occasions in a very hot summer when in the immediate neighbourhood of the outfalls you may perceive a certain odour from the water. I say this is very rare, and that when it does occur it is extremely local; and I think you will find, when I come to analyse the evidence of the witnesses, that with one or two exceptions they were gentlemen who were prepared to say anything. Now my learned friend, Mr. Morice, looks up. Remember that one of his fishermen, the oldest inhabitant of Greenwich, told us how the evidence was got up. A gentleman invited them to the "Golden Anchor," supplied them with pots of

10 April 1883.

porter, and asked them whether they could give evidence against the sewage.

(*Mr. Morice.*) The evidence was got up as evidence is always got up, by getting the people together.

(*Mr. Bidder.*) I am going to read the evidence if it is desired.

(*Chairman.*) Is it worth while going into this?

(*Mr. Bidder.*) You have had it before you, and I say that, when gentlemen are got together like that, they may be expected to be prepared to amplify their recollection; but the actual perception of odour, I venture to say is confined to the reaches between Barking and Crossness and up to Jenningtree Point, and that only on certain days and in hot weather. There is a gentleman, Mr. Beadle, residing at Erith, who gives evidence that he and his men, working upon the Erith mud, found a very offensive smell there; that is quite possible, and the cause of it is very apparent, because, as it is admitted now, and you will hear more about it hereafter, Erith itself pours its own sewage, not into the river as we do, but on to that mud bank, where it lies festering in the sun; so it is hardly to be wondered at that a smell arises.

(*Chairman.*) That is what you say, that it is not to be wondered at that Erith sewage makes a smell, and that your sewage, which is 500 times as much, makes 500 times as much smell.

(*Mr. Bidder.*) But our sewage though it may be 500 times as great, is treated under entirely different conditions. In the first place, a great portion of the decomposition has gone on in the sewer itself; in the second place, we discharge the sewage at high water and into the body of the river, we do not let it trickle out at all times on to the dry mud to ferment upon the mud; the conditions are entirely different, as in that case they present a large amount of nastiness to the sun and to the senses. But I should draw this distinction, that in discussing the scientific evidence you must not disregard the undoubted fact of other and not unimportant sources of pollution in the Thames, especially when you are considering evidence which is given you to lead you to believe that the Metropolitan drainage materially affects the condition of the river above it. There is evidence showing a certain amount of pollution in certain reaches of the river above Barking and Crossness, but it is practically admitted that there are very important sources of pollution other than those of the Metropolitan Board of Works. As one passes up the river, there is the Beckton gasworks; then I come to North Woolwich, a place where a great deal has been said about offensiveness, all we know of that is that there is a sewer discharging into the river which deals with the immediate district. Then we come to the River Lea. There we have the sewage of all West Ham, of 150,000 or 200,000 people, discharged into that river, and the sewage of Stratford; and we have the report of the Commissioner sent down to enquire into that river, who describes the dreadful state of things there. Then we are told that all along in Bermondsey and Rotherhithe there are a number of sewers not yet shut up, and we know that there is a very large floating population. Therefore, whilst I am far from saying that the Metropolitan sewers do not to any extent affect the river above Barking, yet I say you cannot charge us with all the pollution existing in the upper part of the river, for there are sources of pollution, and very important sources of pollution too, which exist in the upper part of the river.

But now, my Lord, I have this pregnant observation to make. There is not a particle of evidence brought before you to show that, as a consequence of our sewage works, there is any low state of health in the districts in the neighbourhood of the outfalls, or along by the river. On the contrary, they are obliged to admit that these are particularly healthy places, that Erith, which for instance has taken such a prominent part in this enquiry, is a place where the general death rate is low, and not only is the general death rate low there, but the death rate from zymotic diseases, which is the class of diseases more directly connectible with such deleterious influences as these are suggested to be, is remarkably low. And moreover, all the witnesses who have been called before you to describe the state of the river are men of remarkable robustness and healthy appearance, and I shall be able to carry that further and show that these districts are remarkably healthy. It is almost shown, I think, by the witnesses who were called. Dr. Corfield could only in one or two cases show any cases of zymotic disease above the average of London, and then it was shown that they were more than accounted for by the peculiar character of the population as compared with the population of Western London. But we shall follow out this into particular districts, showing in what part of the river these diseases occur, and you will find that the river-side parts are remarkably free from those diseases which might be said or thought to be connected with river pollution.

Now, before I pass from that let me remind you that the populations which are more immediately upon the river, for instance, the boys in these training ships anchored in the very sewage flow (and if anybody, if there were deleterious influences, could suffer from them, surely it is those boys), although there have been one or two outbreaks, yet their general health has been exceptionally good, and they continue there to this present day, and the outbreaks which by one or two persons were supposed to be possibly connected with the river were connected with other things, such as trichinosis from eating measled pork. Surely it is a very important fact, when we are talking about the health or injuriousness of the river, when we find what happens with 200 or 300 boys who have been moored there for years and are moored there still. Also the Small Pox Hospital, which has been moored down in a lower section of the river, has been found to be in so salubrious a spot that it has been retained there. Upon the whole, I venture to say there has been no indication of any injury to the riverine or riverside health from the pollution of the Thames, but the contrary.

Now, when I come to turn to the scientific evidence, I shall have a good deal of scientific evidence to put before you, and I will endeavour to show shortly the nature of the evidence which the Metropolitan Board of Works intend to put before you in answer to the evidence on the other side. You have had the evidence of engineers, and you have had the evidence of chemists, and one thing has struck me. I do not know whether it has struck you, viz., the marvellous timidity of the scientific men in venturing to any conclusion; they have put before you masses of figures and wildernesses of tables, but they do not venture themselves. I say it after listening to it very carefully,—to draw the conclusions which their own clients wish them to draw.

Now let me first deal with the evidence of the engineers; they have put before you a lot of hypothetical figures. Shortly, I may condense their evidence as bearing upon the question thus. The proposition they want to establish is that there are always a number of days', say 30 or 40 days', sewage in the River Thames, and that argument is of this kind. We have from analyses by chemists at different parts of the river the amount of chlorine in the water; the amount of chlorine in water, whether it be fresh water or sewage, is relatively so small as compared with sea water that you may call it "nil." For the purpose of comparison, the amount in sea water being very large, being something like 1,960 parts in 100,000, I do not object to that reasoning so far. At any point of the river, given an analysis, you may say the water there is so many parts sea water and so many parts fresh water. I do not object to that; but they go further and they say, What about the fresh water? They go to the Returns of the Metropolitan Board of Works, and say that on such and such a day you discharged so many cubic feet of sewage into the river; on the same day there were so many million

cubic feet of upland water coming into the river from Teddington and other places, and consequently we at once assume that the proportion of the fresh water which is sewage is that proportion—it may be one-eighth or it may be one-tenth. Thereupon, applying that over the whole river, they say that at Gravesend, or at other places, the chlorine tells us that, say, 20 per cent. is fresh water; the gauging tells us one-tenth of that is sewage and the rest is upland water; consequently we tell you that 2 per cent. of the whole river at that point is sewage. So we work out the calculation, and tell you that there are so many days' sewage between Crossness and Erith, and so many days' sewage between Erith and Southend.

Now I will show you two radical answers which make that calculation totally worthless; it is based upon the assumption, which everybody knows to be contrary to fact, that once sewage, always sewage,—that the sewage, being poured in at Barking in the proportion say of 1 to 10, and that sewage oscillating backwards and forwards, though it may be 20 days hence at Gravesend or Southend, they still label it sewage, though everybody has said, and Dr. Tidy has admitted (the question of rate being matter of discussion), that, as a matter of fact, the sewage is burnt up and decomposed, and ceases to be sewage just as literally as, if your Lordship put that envelope into the fire, it would cease to be paper.

(*Chairman.*) Would that destroy the chlorine?

(*Mr. Bidder.*) No, it would destroy the sewage. I admit the chlorine argument, that, if you find a certain number of grains of chlorine at a certain time and place, you can say with a certain accuracy that that indicates a certain proportion of sewage or fresh and sea water.

(*Chairman.*) I think what you mean is that it may show what is or had been sewage, but it does not show that it is then existing sewage.

(*Mr. Bidder.*) Exactly so, my Lord, it is just that step that is fallacious. All you can say is that a certain portion of that is liquid which once was sewage, and you can say that of every drop of rain water, I suppose, that comes from the heavens.

(*Chairman.*) Your argument is something like this, if I understand it,—that if you were to put into a bucket containing nine parts of pure water, with the ordinary quantity of oxygen in it, a tenth part of sewage, so as to make 10 parts, and you shook them all up,—that at the end of 24 hours a tenth part of that mixture would not be sewage.

(*Mr. Bidder.*) That is what I say, and what men, much more competent to form an opinion upon the subject, say is beyond dispute.

(*Chairman.*) I do not think there would be much dispute about it.

(*Mr. Bidder.*) But the engineers deal with it as a simple arithmetical problem, and ignore absolutely the chemical aspect of the question.

My second observation is of another character, that when you go to the lower end of the river, which it is convenient to take (of course there is no line between where it ceases to be river and becomes sea, but Southend Pier would be a convenient point to take), it is a convenient fact to remember that, in round numbers, taking the tidal part of the river above Southend, there is just twice as much water in it at high water as there is at low water—that is to say, every 12 hours one half of all the water that was above Southend Pier has gone to sea, and that there comes back again an equivalent quantity of water upon the next tide. And although there is that immense quantity of water swept past Southend to join the sea, yet they make this astounding assumption that there is no admixture with the sea, that it is labelled and ticketed as it goes out, and is regarded as coming back without any admixture with the sea. You will find that they actually assume that in every tide there goes to sea from Southend five days' sewage of London, which five days' sewage of London comes back just as safely as if it had been bottled up and labelled, and brought back free from any admixture with the general sea. It is ridiculous.

I now pass from the evidence of the engineers, and come to the evidence of the chemists. Now I say they do not venture to assert. When I have to refer to the evidence hereafter, I shall show you how carefully they avoid asserting that the condition of the Thames is dangerous, but they give certain figures and they say, here is evidence of a great pollution. I am not here to assume that the Thames water, after it has received the sewage, is as pure as it was before it received the sewage. I say the question is one of degree,—and whilst I admit that there is pollution, I shall, I trust, satisfy you that that pollution is not of so serious an extent as to interfere with the comfort of those who are interested in the question. I think I may put aside the very sensational statements which have been made, which might have gone down with a jury, but which were hardly worth while advancing to a body like the Commissioners; such as that there are 100 tons of sewage matter (with the great emphasis on the "tons") put into the Thames every 24 hours; because I could make a similar statement. I took the trouble to see what that 100 tons meant in another way. I found it amounted to the 20th part of a grain in each gallon of water—about as much as you could balance carefully upon a moderate-sized pen—that is about an equally valuable statement. But I will come to questions which are more important. They admit, that partially at any rate, the process of burning up the sewage and destroying it is undoubtedly going on. Dr. Tidy admits it, and Dr. Frankland admits it, though not to the same degree. Professor Way admits it, and he says the fate of the sewage is to go up sometimes to sink and sometimes to rise, and to evolve gases until it is destroyed, which is another way of saying the same thing as I and my witnesses say.

Now, that is really practically the very centre and core of the answer of the Metropolitan Board of Works. True it is that we put this large body of sewage into the river, but what happens when it goes into the river is not that it remains in the river as a polluting mass, but that it is put into such an enormous quantity of water that there is abundant opportunity for the operation to go on which is now perfectly well recognized and is seen in various rivers; that decomposition and burning up of the sewage goes on, and, before a very long interval has elapsed, it is entirely burnt up and destroyed as sewage. I cannot do better than put before you the words of Dr. Tidy, who has studied the question for years, who has maintained here the position he has always maintained, and, as I ventured to think, with very good reason, and who has summed it up concisely in these words: "If you put sewage "into pure running water in the proportion of 1 part "to 20, and let that go on for a run of 10, or 12, or 14 "miles, that sewage is absolutely destroyed"—that is Dr. Tidy's evidence—that is the result of years' experiments by Dr. Tidy and others who think with him. Just let me read what I read to Dr. Tidy in his own words: "Given then a fairly rapid river that "has received sewage in quantity not exceeding, say, "one-twentieth part of its volume, is there evidence "to prove that after the run of a few miles the water "of that river will regain its purity and become" (not merely not injurious to people who live upon the banks) "wholesome and good for drinking. To this "question I answer unhesitatingly, there is undoubted "evidence of such purification, and the evidence I "have adduced has been of a fourfold nature, physical, "chemical, medical, and statistical." That is a summary of a long argument and a summary of statistical observations in various places. Dr. Tidy has shown, by carefully carried out experiments in his laboratory, that it is so, and he has demonstrated that in nature it is so. Now, what is the fact here? We do not put in sewage in the proportion of 1 to 20—it is less than 1 to 200—it is 1 in 215; but it is said, "You must not assume because that proposi "tion is true, that, therefore, your sewage vanishes "in that way." Why not? "Because you do not "put it into pure water—you put it into water that "is already pollute and has not got that purifying

10 April 1884.

"power that I assume in the case of a pure river." There, again, it is only a question of degree. Although it is not unpolluted water, yet it differs from it in a very small degree, as I will show when I come to speak of the analysis, and that, allowing for all that difference, there is an enormous margin.

Now I turn from theory to fact, to see how it supports my view. I take the analysis which we have taken for the purpose, indeed I intend to take Dr. Tidy's own analysis of the river, and the other which has been put in, and what do I find? That, whether I test it by the albumenoid ammonia, which some chemists consider a valuable test of sewage contamination, or whether I test it by the amount of oxygen which is required to burn up the oxidisable matter in the water, which is also very valuable, and, as many chemists consider, if properly applied, a crucial test, or, in whatever way I test it, I come to this broad result, which you will find is borne out by Dr. Tidy's analyses. I begin at Teddington, with water pouring over it, which is treated here as pure water—at any rate, it is sufficiently pure to be that which is drunk by a large part of London—and let me remind you of a remarkable fact as the best example I can give you of the truth of the proposition I am enunciating, that the Teddington water is water which has received the sewage of a million of people. It is not perfectly pure water, but has a certain amount of pollution; and there is a certain amount of increase, I do not dispute it, until you come further down—until you come to the Barking outfall; the pollution between there and Teddington Weir has increased between two and three times. I do not mean taking a sample of the sewage flow as it comes out of the sewer or in the black line of the sewage, but I am speaking of the general river, and I say you will find that, whereas the general pollution of the water at Teddington is as one, and at Barking is as two and a half—at Erith it begins to fall—at Purfleet it has fallen very much, and by the time you get to Gravesend it is reduced to the purity of Teddington again. That is a fact which analysis will bring distinctly before you, the effect produced in the river by this mass of pollution—so extraordinary a mass of pollution that its extent, as compared with the water at Teddington, is about $2\frac{1}{2}$ or something under 3 to 1; yet, by the time it has got to Gravesend, all trace of that sewage has vanished, and the river is again as pure as it was when it came over Teddington; of that I shall be able to satisfy you demonstrably.

(*Mr. Abernethy.*) Dr. Tidy's answer was applying to a river flowing continually in one direction.

(*Mr. Bidder.*) I am very much obliged to Mr. Abernethy for reminding me of that. I vainly endeavoured to elicit what the magic of flowing in one direction was, because, of course, it is the motion and the mixture that are the advantage of the flowing over stagnation; but flowing in one direction is no better than flowing in another, except that one knows, in order to stir up things thoroughly, after stirring in one direction, one is apt to get a better mixture by stirring in the opposite direction. But I say, here is the fact you may tell me my theory is wrong if you please, but I fall back upon the facts, and I say the analyses show that, although the effect of my sewer is that there is an increase from 1 to $2\frac{1}{2}$, yet, as you get further down, that disappears altogether.

Now it is very interesting to trace out the line of thought which was indicated by Professor Way. Simultaneously with that operation, the result of which I have described, we find, as Dr. Tidy has shown us, a diminution in the oxygen, so that where there was, as I said, nearly two inches above, it has fallen to only half an inch of oxygen in the gallon below. But that is not all you find, because you find this very interesting fact that is brought out by that analysis, that an ebb tide which has received its charge of sewage at Barking and Crossness arrives at Erith and Purfleet, as one might say, almost exhausted of its oxygen, and it comes back a few hours afterwards from the direction of the sea re-charged with oxygen; and there is that operation going on every tide, the oxygen being consumed by each charge of sewage, and the water going out and coming back re-charged, ready for another charge of sewage. Says Professor Way, it would want 100 tons of oxygen to burn it up. Now we have taken the trouble to calculate how much oxygen is brought up every tide, and we find it is more than 100 tons, it is 200 or 300 tons. No doubt, Professor Way is right in saying that to burn up this sewage would require 100 tons or more of oxygen; it is easily demonstrable from the difference between the quantity at ebb and flow of the tide that a quantity equal to between 200 and 300 tons of oxygen is introduced with each flow of the tide.

Now, another thing is this, that if the river were not equal to its work it should have got worse, but it does not get worse, and I shall prove to you that the analysis shows the condition of the river to be as good now, at all events, to be no worse than it was years ago. If it were true that the river could not deal with the sewage, but that a part of it fell undecomposed, and was constantly accumulating on the banks and in the bed of the river, there ought to be a deterioration; but there is not, and that I shall show demonstrably from analysis. Other causes I shall show you in passing, but evidence will be given by witnesses, who will bring it out more distinctly than I can now do, that it is not a mere question of the oxygen in the water, which is the purifying agent, but there is a cause which has been overlooked upon the other side, and which our researches show is a very important one. An enormous quantity of this sewage is consumed by minute organisms of animals which feed upon it, so that it is their meat, and it ceases to be sewage. A great deal is disposed of by animalculæ; then again there are, no doubt, a quantity of algæ and minute plants of low organization which produce oxygen in the water. All that I leave to be described to you by scientific witnesses; but I cannot forbear noting one branch of evidence, and that a very important branch of evidence. You had some evidence from Dr. Tidy and Dr. Lionel Beale of a microscopic character, but I will take Dr. Tidy's evidence; he says, "I took specimens of mud and "stirred them up in a glass, and after a certain sub-"sidence I got a flocculent film at the top of the "subsiding matter, which I took out with a pipette." Then he described what he found from having examined it microscopically, Dr. Tidy admits that those are qualitative and not quantitative; he says, "I admit "that I can detect particles which are of sewage "origin, but they do not in any way indicate that "there is 10 per cent., 5 per cent., or 1 per cent., or "one part in 100,000." Now, I shall show you, by very careful miscroscopical researches of a character, I venture to say, almost unprecedented, that we have been able to go a great deal further than that; that we have been able, both as regards the mud and as regards the suspended matter of the river, to trace the matter both quantitatively and qualitatively. We shall be able to show that the quantity of that sewage matter is so small compared to the general mud of the river as to be quite inappreciable.

I think you will understand that the case we have to present to you is that that which is true in other cases is true here,—that the principle Dr. Tidy lays down applies here, and that the analyses of the other side and our own analyses concur in this, that that operation does go on, and go on effectively, and that the river is more than sufficient for the work; that that pollution which arises between Teddington and Barking disappears before you get to the sea entirely and absolutely. We shall confirm that by microscopic analyses of the mud and of the river, and I think you will be constrained to come to the conclusion that, whilst of course nobody in his senses would pretend that, if you put in the sewage of 4,000,000 people, you will not be able to smell it, yet that there is substantially no deleterious or injurious effect produced by it, and that it would be a monstrous thing that the Metropolis should be saddled with an

expenditure of millions of money in order to get rid of a local nuisance, which would not be to transfer it to another part of the river, for it would be impossible to find a more abandoned place, or a place more utterly and unrestrictedly useful for such purposes, as those for which the present site is now used. 10 April 1883

Adjourned to to-morrow at 8, Richmond Terrace, at half past 12 o'clock.

# No. 8, Richmond Terrace, Whitehall.

## THIRTY-SECOND DAY.

### Wednesday, 11th April 1883.

PRESENT:

The Right Hon. LORD BRAMWELL, F.R.S., in the Chair.

Sir John Coode, Mem. Inst., C.E.
Colonel C. B. Ewart, C.B., R.E.
François de Chaumont, Esq., M.D., F.R.S.
James Abernethy, Esq., F.R.S.E., Mem. Inst. C.E.
Wm. Pole, Esq., F.R.S., *Secretary*.

Sir Joseph William Bazalgette, C.B., called again and further examined.

*Sir J. W. Bazalgette, C.B.*

11 April 1883.

12,494. (*Mr. Norman Bazalgette.*) Before I go to your proof I believe you have a table of the areas at the present time draining to the Main Drainage sewers which you are anxious to put in?—I have. The areas which were drained had not been computed up to a recent date when I gave my evidence in the first instance; and I have since had the additional areas which have been drained added to them and brought up to the present time, they are contained in that table with some particulars both as to areas within the Metropolis and those which are outside the Metropolis. I do not know whether I need go through the figures in detail, but I can state generally that they show upon the north side that the area drained at the present time is 48½ square miles. Outside the Metropolis, Kilburn and South Hornsey add 1·71 square miles, and Hornsey equal to 1·75 square miles, making a total of 51·96 square miles, say 52 square miles upon the north side, Then upon the south side the area drained within the Metropolis is 51·21 square miles, outside the Metropolis Norwood adds ·54 square miles and Beckenham an area equivalent to ·03 square miles, taking the sewage of 5,000 people; making in all 51·78 square miles now draining into the system upon the south side. That leaves 16·57 square miles undrained, of which half a square mile consists of commons, parks, and water.

12,495. (*Chairman.*) Are you on the north side now?—No, upon the south side; 3½ square miles consist of marsh lands, and 2¼ square miles drain away from the Metropolis towards the River Cray, making a deduction from that 16½ square miles of 6·15, leaving 10·42 square miles not drained into intercepting sewers. Now those consist mainly of either agricultural land or of nursery gardens or houses such as there are at Roehampton, Eltham, and Mottingham, which have large grounds attached to them and which have a very small population upon them indeed.

12,496. (*Mr. Norman Bazalgette.*) Are they areas which in your judgment are likely to be soon built over?—No

12,497. (*Chairman.*) What becomes of the drainage of those places, they are not drained at all, perhaps?—The sewage, if any, upon them, is disposed of upon the lands themselves; at Roehampton the land drains into the Wandle, at Mottingham into the Cray, and at Eltham partly into the River Lee, and partly into the Cray. I may say the sewage is disposed of upon the land.

12,498. (*Mr. Norman Bazalgette.*) I believe Beckenham contributes sewage only to the main drainage system?—Yes; but I have taken the sewage as representing the small area from which we should get both sewage and rain.

12,499. (*Chairman.*) Does the undrained part drain into the Thames both north and south?—Yes, mainly it drains into the Thames, that is to say, the 10 miles.

12,500. Does the part which is not drained into the intercepting sewers drain into the Thames in any way?—Yes, it is in the Thames basin certainly; its rainfall passes into the streams.

12,501. But the sewage does not drain into the Thames?—No, it probably never will come into our drainage system.

12,502. Is there any metropolitan sewage that drains into the Lea which gets into the Thames that way?—No, it is all intercepted.

(*The tables were handed in, see next page.*)

12,503. (*Mr. Norman Bazalgette.*) Now we will deal with Mr. Baldwin Latham's criticisms upon the main drainage first. I do not propose to read the evidence which he gave to the Commission, but if they will allow me I will state it shortly and refer them to the questions and answers. Mr. Baldwin Latham, at Nos. 7765, 7768, and 7779 quoted your evidence, I believe, on the great London Drainage Bill of 1853, and drew the inference from it that there would be an overflow from the present system into the river upon occasions varying from 80 to 100 days; what do you say with respect to that?—First, I say with respect to that, that any opinion which I might have expressed in 1853 about the scheme before I prepared any scheme myself, can hardly be taken as evidence of what is taking place at the present time; but the conditions to which I referred at that time were very different from the conditions of my own system of drainage, that is to say, whilst the great London drainage scheme proposed to deal with 43 square miles, they proposed to intercept the sewage of that 43 square miles by one sewer only of 10 feet in diameter.

12,504. Whom was the great London drainage scheme prepared by?—I can hardly tell you that. The promoter of it was a Mr. Morewood, who was not an engineer, but he had some engineers supporting it in Committee.

12,505. You were not responsible for that system?—No. The great sewer was to be capable of discharging 19,000 cubic feet a minute, whereas my three northern outfall sewers when united in one are capable of discharging 33,000 cubic feet a minute. I deal with a larger area, but if you reduce it to the same area you will see I have provided 50 per cent. more discharging power from the same land than this great London drainage scheme had done. I gave evidence in 1853 before the Committee that if that scheme were carried out, in my judgment there would be an overflow into the Thames on from 80 to 100

5th April 1883.

*Sir J. W. Bazalgette, C.B.*

11 April 1883.

| Areas from which Sewage is intercepted. — North Side of Thames. | Inside Metropolis. | Outside Metropolis. | Total. | Length of Main Intercepting Sewers, including Branches. | Dimensions, Largest and Smallest. | Inclinations, Greatest and Least. |
|---|---|---|---|---|---|---|
| | Square Miles. | Square Miles. | Square Miles. | Miles. | | Feet per mile. |
| High Level | 8·29 | — | 8·29 | 7½ | 9′ 6″ × 12′ 0″ / 4′ 0″ Bl. | 75 to 4. |
| Mid Level | 16·47 | Kilburn 1·34; S. Hornsey 0·37; 1·71 | 18·18 | 12¾ | 10′ 6″ Bl. / 4′ 0″ × 2′ 8″ | 17½ to 2. |
| Low Level, including Western Division | 23·74 | — | 23·74 | 21 | 10′ 3″ Bl. / 3′ 9″ × 2′ 6″ | 10·37 to 2. |
| Outfall Sewer | — | | — | 5½ | 3 Culverts, 9′ 0″ × 9′ 0″; 2 Culverts, 9′ 0″ × 9′ 0″ | 2. |
| | 48·50A | | 50·21C | 46¾ | | |
| Area of Metropolis [North] *not* drained into intercepting sewers. | 1·47B | | | | | |
| | 49·97 | | | | | |

A. Of this area 3·40 square miles is common or park land, and 0·87 square miles is water.

B. This area consists of parts of Hackney Marshes, North Woolwich, and a detached part of the Metropolis near Muswell Hill.

C. In addition to the above, the district of the Hornsey Local Board contributes sewage from a present population of about 22,000, the quantity being restricted ultimately to 500 cubic feet per minute. A part of the Stamford Brook drainage area contributes also the sewage from a small population, but its number cannot be ascertained. The same area also contributes surface water to the Metropolitan system, but the Metropolitan Board have determined to intercept this from their sewers and discharge it into the river at the extreme western boundary of the Metropolis. This is one of the works included in the 1,500,000*l.*, to be expended to prevent floodings from rain.

| Areas from which Sewage is intercepted. — South side of Thames. | Inside Metropolis. | Outside Metropolis. | Total. | Length of Main Intercepting Sewers, including Branches. | Dimensions, Largest and Smallest. | Inclinations, Greatest and Least. |
|---|---|---|---|---|---|---|
| | Square Miles. | Square Miles. | Square Miles. | Miles. | | Feet per Mile. |
| High Level | 24·71 | Upper Norwood, 0·54 | 25·25 | 14⅝ | Two 10′ 6″ × 10′ 6″; One 3′ 0″ × 2′ 0″ | 52·8 to 2½. |
| Low Level | 20·72 | | 20·72 | 14⅛ | Two 7′ 0″ × 7′ 0″ / One 4′ 0″ Bl. | 4½ to 2. |
| Outfall Sewer | 5·78 | | 5·78 | 7⅓ | 11′ 6″ | 2. |
| | 51·21D | | 51·75F | 36¼ | | |
| Areas of Metropolis (South) *not* drained into intersecting sewers. | 16·57E | | | | | |
| | 67·78 | | | | | |

D. This contains 3 square miles of common land and park, and 0·56 square mile of water.

E. This contains ½ sq. mile of common land and parks, 3½ square miles of marsh lands, 2·15 square miles draining away from the Metropolis, and the rest is land of a rural or agricultural character, situate in the localities of Roehampton, Eltham, and Mottingham, which will never probably be more than sparsely built over.

F. In addition to this, 0·92 square mile of Beckenham contributes sewage only to the intercepting system.

days in the year. Mr. Baldwin Latham says, if that is so there must be an overflow from your sewers on from 80 to 100 days in the year. I say the argument is not correct, and I shall show by-and-bye that the deduction is not correct.

12,506. (*Chairman.*) You say the deduction is not correct, because you have given a larger discharging capacity?—I have given a larger discharging capacity, that it is larger in proportion to a given area than that scheme proposed upon the north side; then upon the south side it is very much larger. Upon the south side the area to be intercepted by the great London drainage scheme was not stated, but the discharging capacity of one sewer, 6 feet in diameter, was to be 5,300 cubic feet a minute, whilst the discharging capacity at my outfall sewer for the south side is 19,000 cubic feet a minute, or 3½ times the discharging capacity of the great London drainage scheme outfall.

12,507. (*Mr. Norman Bazalgette.*) Then I think we may deduce, as a matter of course from what you

have told us, that, assuming the great London drainage scheme were discharging with its limited capacity, assuming that there were an overflow from it on from 80 to 100 days in the year, it does not follow that there would be the same overflow from the intercepting system?—No.

12,508. I will deal next with Mr. Baldwin Latham's allegations in his answers to questions 7456, 7749, and 7751, where he states that no provision was made in the discharging capacity of the outfall sewers for the sewage of the western district; what do you say to that?—You will remember that when we designed the main intercepting system it was proposed to take the greater area upon the north side of the Thames to the outfall at Barking; but it was proposed to take the low-lying district at the western end and deodorise its sewage, that is, as regards the western district. A design was got out in the first instance with that view. Subsequently it was determined not to deal with the western district by deodorisation, but to connect it with the main system, and take the whole to Barking. Now, Mr. Baldwin Latham argues upon that, that the outfall sewers had been designed for a district without the western district, and that when the western district was added to it the outfall sewer was so small that it was not of the right proportion. I will show you that he is incorrect in that statement. This is my Report of 1856, in which very careful calculations have been made, showing at every point of the intercepting sewer what quantity would come in at those points, and making up the total quantity to be carried off. That quantity is made up in this way: we take the sewage at so many gallons a head. We take the maximum flow at double that quantity, and then we take a quarter of an inch of rain running off added to that, and taking the populations and the areas, we arrive at each point at the quantity to be intercepted. Now, that table shows that the quantity to be intercepted by the northern high level sewer after it had accumulated it all and got to the eastern end of London, amounted to 3,965 cubic feet a minute, the middle level sewer to 14,345 cubic feet a minute, and the low level sewer to 9,130 cubic feet a minute, together making 27,440 cubic feet a minute; and the western district gave 5,130 cubic feet a minute. Including the western district, therefore, the total quantity to be intercepted was 32,570 cubic feet a minute. Now, Mr. Latham has already told us, and it is a fact, that the outfall sewer will discharge 33,000 cubic feet a minute.

12,509. Those are the three outfall sewers, the high, the low, and the middle level?—Yes, the three sewers; each will discharge 11,000 cubic feet a minute; therefore the outfall sewer is a proper size for taking off the whole of the sewage of the western district. Mr. Latham said: Yes, you were constructing the outfall sewer before you determined to take the sewage of the western district into it. That was quite true; we were. But we knew that we must have made these sewers 8 feet 6 inches in diameter to take off the sewage of the high, low, and middle level sewers without taking the sewage of the western district; and we also knew there were differences of opinion as to whether the western district should be dealt with by itself or brought into the main system; therefore we said, we had much better make our sewer of 6 inches larger diameter in case the western sewage should be brought ultimately into the system; and we were making those sewers when it was determined not to deodorise the sewage of the western district, but to carry it into the outfall sewers.

12,510. (*Chairman.*) I should have thought the question was not so much what you had calculated or arranged, but what is the fact now; do the sewers carry off the requisite quantity?—Yes, they do.

12,511. I should have thought that could have been proved as a matter of fact; you have gauged the quantity discharged.

12,512. (*Mr. Norman Bazalgette.*) Is the western district at the present time drained into the outfall sewers?—I think, if you will let me put it in this way first, I shall come back at last to what you desire.

12,513. (*Chairman.*) I can quite understand that you are very desirous of showing that your calculations are right, but you must take care that you do not overload my memory and faculties with figures and facts?—I only desire to satisfy the Commission as to the precise position of things.

12,514. (*Mr. Norman Bazalgette.*) I think we might dispose of it in this way; is the western district at the present time drained into the metropolitan outfall sewer?—Yes.

12,515. And there is sufficient capacity in this sewer for so draining it?—Yes.

12,516. So that Mr. Baldwin Latham is wrong in saying that it was not provided for in the first instance?—Yes.

12,517. (*Chairman.*) You say, as a fact, that the sewers are large enough, and do carry off the sewage, except when there is a rainfall above a certain amount?—Yes, I do.

(*Chairman.*) Is that disputed?

(*Mr. Webster.*) I do not quite know in the way in which Sir Joseph Bazalgette puts it, whether it is or not; it is a question of degree how often they do and how often they do not.

(*Chairman.*) As I understand, if there were no rainfall they would always carry off the sewage.

(*Witness.*) Yes, they would.

(*Mr. Webster.*) I think in all probability that is the fact, but I must not be taken as exactly admitting it.

12,518. (*Chairman.*) The next question is, what quantity of rainfall would make them insufficient?—Yes, that is so; we shall come to that point directly.

(*Mr. Webster.*) I do not think Mr. Latham anywhere said that if there were no rainfall the sewers were not sufficient to take off the sewage alone.

(*Chairman.*) He rather suggested to us that Sir Joseph Bazalgette had lost sight of certain matters, and consequently had not made adequate provision. I can quite understand that Sir Joseph Bazalgette would controvert that, but after all it comes to this, are they sufficient, and he says they are.

(*Mr. Abernethy.*) Plus the $\frac{1}{4}$ of an inch of rainfall.

(*Witness.*) It is difficult to give it in two words without following out the reasoning.

12,519. (*Mr. Norman Bazalgette.*) The next allegation of Mr. Latham's is that no rainfall could have been discharged at Barking in 1875; that will be found in answer to questions 7739–40. As these are two short answers, I may as well read what Mr. Baldwin Latham really did say. At question 7739 he was asked, "What you mean is, that the amount that actually "flowed off at Barking in 1875 was below what is "found to be a correct estimate of the sewage "per head"; to which he replied: "That is so. "(*Q.*) And of rainfall at Barking that year"—that is, in 1875—"there was none that flowed off?—"(*A.*) Although there were 29 odd inches of rainfall "that year there was not any that flowed off at "Barking." What do you say to that?—Mr. Baldwin Latham arrived at that conclusion upon two assumptions; one was that the water-supply was the same upon the north side as upon the south side in cubic feet per head, whereas upon the north side, in answer to question 7726, he has correctly stated the water-supply upon the north side to be 30·4 gallons per head; so that he had overstated the water-supply, and he had also not drawn attention to the fact that the sewerage of the western district in those two years, 1875–6, had not been diverted to Barking. Now, making allowance for those——

12,520. (*Chairman.*) Let me see if I understand exactly the effect of your answer. When he says that "the amount that actually flowed off at Barking in "1875 was below what is found to be a correct "estimate of the sewage per head," does that mean therefore that some of the sewage must have found its way into the river by the overflow sewers?—Yes, that was the assumption.

12,520*a*. That is what it means?—Yes; Mr. Baldwin Latham's statement is, that taking the years 1875 and

*Sir J. W. Bazalgette, C.B.*

11 April 1883.

1876 you had not the full water-supply or scarcely anything over the water-supply coming down to Barking; therefore all your rainfall must have gone into the river by the overflows. Now that was a mistake upon the ground——

(*Chairman.*) Not only all your rainfall, but some of your sewage, because it was "below what was "found to be a correct estimate of the sewage."

(*Colonel Ewart.*) A mixed volume in proportion to the amount of the rainfall.

(*Witness.*) In the first place the water-supply was estimated at 31¼ gallons per head of the population instead of 30·4 gallons, as it should have been; and in the next place it was estimated upon the population of the western division; whereas the system was not complete in those two years, and their sewage was not then coming down. If you take what was actually taking place upon the north side in the year 1881, when we have the actual population and can get at it more correctly therefore, you will find that the daily discharge of sewage at Barking would be 77,739,032 gallons, which, deducted from the total quantity discharged at Barking, namely, 89,404,916 gallons, leaves a surplus of 11,665,884 gallons, or 1,866,525 cubic feet for a rainflow for 51 square miles, which is equal to 36,600 cubic feet per square mile, or $\frac{1}{6\cdot3}$ of an inch in depth for every day throughout the year. Now that represents in 365 days a total depth of 5·8, nearly 6 inches of rainfall, running off at Barking. Six inches of rainfall running off at Barking would represent nearly half the annual rainfall, as I shall show you presently that 6 inches running off represents very nearly 12 inches falling.

12,521. (*Chairman.*) Taking 12 inches as falling, that is half the rainfall?—Yes.

12,522. Even this seems to me to be a comparatively small matter, because they complained of the fouling of the water from sewage not being conveyed to Barking, but escaping at an earlier part of the river; there is just a little evidence that it is fouled, I think?—Mr. Baldwin Latham's evidence went to this: You are discharging sewage up in London at the overflows much more frequently than you have led us to suppose; and he set to work to prove that in a variety of ways. I am endeavouring to show that the different ways in which he set to work to prove that are not correct; that his data are not correct, and do not lead to that inference; and I also propose to give you some evidence of what actually has taken place besides. Still it seems to me necessary to meet each of the allegations, otherwise they stand as if they were correct.

12,523. But I mean the main battle has been upon the condition of things about the overflows?—I will take it very shortly.

12,524. (*Mr. Norman Bazalgette.*) Now we will go to question 7710 of Mr. Baldwin Latham's evidence, which I will read: "Taking a dry season would show "that what has been discharged would not come "from rain?—(*A.*) That would show that what had "been discharged then could not possibly come from "rain. The result of this showed that on the 12th July "1876 the quantity discharged in gallons at Crossness "on this particular day was 52,256,223 gallons, and "that was an excessively dry period; in fact, the "month of July was one of the smallest rainfalls that "ever was recorded, there had been no rain from the "24th of June to the 6th of July. On that day at "8 p.m., the sixteenth of an inch fell, and ·01 upon "the 7th, and ·02 upon the 8th, and then upon the "12th these experiments were commenced, and were "conducted throughout the day. Then from the "table of population in 1876 you will see that there "is a little over 1,000,000 of population and "52,000,000 gallons of sewage, so that you have "50 gallons per head, that is 30 of sewage proper "and 20 of leakage as I have already stated." What do you say as to Mr. Baldwin Latham's allegation that in July 1876 there were 20 gallons of leakage per head of the population discharged at Crossness?—Here Mr. Baldwin Latham has taken the water supply again on the south less than the actual supply, that is to say 51¼ gallons per head; but the water supply of the south side is larger than on the north, the average of the two is 5 cubic feet a head, but upon the north side it is smaller per head, and upon the south side it is larger per head, it is 32·5 gallons. Mr. Baldwin Latham's estimate was arrived at taking it upon that view that 30 gallons was sewage proper and 20 gallons derived from leakage, that he says in answer to question 7733; but he admits that the quantity discharged was at the rate of 46·88 gallons per head if estimated upon the entire southern population; and then he throws out 24 square miles and assumes 69,000 persons residing upon that 24 square miles which do not drain into the system; but I have shown upon the amended table which I have put in that the drainage area has been extended since that period, and that practically the whole of the population is draining into it and will do. I have also reduced the area not drained to 10 miles under the extended drainage system, upon which there is a very small population. The greater portion of this area consists of such places as Plumstead and Greenwich Marshes, open lands surrounding Eltham and Bromley, Tooting and Roehampton, Bosthall Heath, Woolwich, and Plumstead Commons, Blackheath, Tooting, Clapham, Wandsworth, Putney, Wimbledon, Streatham, Peckham, and other commons and suburban parks. Now the actual discharge upon that day was at the rate of 46·88 gallons per head, and if you deduct from that the actual quantity, the 32½ gallons instead of leaving 20 gallons to be accounted for it leaves 14·38.

12,525. Which upon Mr. Baldwin Latham's showing would be called "leakage"?—Which Mr. Baldwin Latham said he assumed to be leakage.

12,526. How do you account for the 14 gallons?—That 14·38 gallons per head amounts in point of fact to 16,000,000 gallons a day; that is to say upon a dry day after taking the water supply to the population there was an excess of 16,000,000 gallons a day to be accounted for. Now that is to be accounted for in two or three different ways. I will first refer to a report which I made upon the Bermondsey inlets. The Bermondsey tanneries have two inlets into the Thames which have been the subject of great trouble to us for some years, they have the right of letting in the water from the Thames into their tanneries, and they let it in in very large quantities, and we have to deal with it in the sewers. On the 9th of January 1877 I reported upon the subject.

12,527. (*Chairman.*) Let me see if I appreciate this matter. This is no imputation upon your calculations, but it is a suggestion that from leakage the sewers are not adequate?—That is the purport of it. I almost think I had better read the whole report, it is not a long one,

12,528. (*Mr. Webster.*) What is the date of that report?—The 9th of January 1877. The report is as follows, "Under the several Commissions of Sewers "that preceded the present Metropolitan Board of "Works, a culvert, two feet in diameter, which "supplied water from the Thames at St. Saviour's "Dock, Bermondsey, to certain tan yards right and "left of Russell Street, Market Street, &c., was under "the control of those Commissioners. Their sluice "keeper admitted the water and shut it off for the "benefit of those who were entitled to the supply, "subject to the safety of themselves and their neighbours being secured. In those days any excessive "admission of water charged the comparatively "small, shallow, and tide-locked sewers; but when "the main drainage system was constructed, water "might be admitted without check, as the surplus "ran off into the deep main sewers and was carried off "by the pumps at Greenwich and Crossness. Since "the year 1855, that is from the constitution of the "present Board, the control of the culvert has been "under the vestry of Bermondsey, and the quantity "of water has greatly increased. The water may be "seen flowing through the tan yards unchecked, and "the experience at the Deptford pumping station is

" that, even in the most dry weather, the quantity of " water which has to be pumped greatly increases as " the tides increase in height to spring tides. At " *ordinary* tides the calculated quantity of water " which can be taken by the culvert alone is 2¼ " million gallons in 24 hours, or nearly one-twelfth of " the daily average at Deptford pumping station. " At spring tides this is much increased. It seems to " me that the Metropolitan Board of Works might " fairly ask Parliament to put the control of this " important inlet into their hands. As steam power " for manufacturing purposes increases in the Metro- " polis the quantity of clear water used for condensing " also increases. One large mill in Belvedere Road, " near Waterloo Bridge, sends between a quarter and " half a million gallons into a district sewer from " whence it passes into the main sewers. If possible " some check should be put upon this." Then again upon the 13th of May, 1881, I reported upon the same question, " Since the completion of the low level system " of drainage, very large quantities of water are allowed " to flow unchecked through the culvert into that " system, thus increasing the cost of pumping at " Deptford and Crossness, and hence the necessity for " the Board having the control of the culvert. The " Board fully recognised this necessity, and by their " direction a clause was inserted in the Thames Flood " Bill for the purpose of securing to the Board such " control, but the clause, in consequence of some " opposition in the Select Committee, was ultimately " withdrawn. I have now reason to believe that if " a representation were made to the vestry of " Bermondsey they would be likely to accede to the " proposition that the culvert in question and an " 18-inch iron pipe at Bermondsey Wall, which " supplies some of the tanneries with water, should " be taken charge of by this Board, provided that all " existing rights were respected." Now these culverts and the water supply for the manufacturing purposes took off at least 4,000,000 gallons per diem let into the sewers. That accounts for one-fourth of it. Then the sewers upon the south side, which were constructed many years ago in a flat district, are exceedingly flat, having very little fall, and they are apt to accumulate deposit, and for the purpose of removing that deposit there are 40 inlets, one half of which are under the control of the Metropolitan Board of Works, and the other half under the control of six of the vestries.

12,529. (*Mr. Norman Bazalgette.*) Or district boards, as, I believe, some of them are?—Or district boards.

12,530. Will you state what they are?—Wandsworth, Lambeth, St. Saviour's, St. Olave, Bermondsey, and Rotherhithe. Now that flushing is carried on daily in dry weather by gangs of flushing men, who take certain lengths and flush them out on different days, they do not keep any record of the way in which they flush them, and I have been unable to get at the quantity either from them or the district boards. I have been taking some trouble to try and arrive at it, but I cannot do so. All I can say is, that without being able to give an estimate of the quantity, to the best of my judgment it may be fairly assumed that one-fourth comes from manufactories and tanneries, probably another fourth comes from the Board's flushing, another fourth from the flushing of the district boards, and the remaining fourth from leakage; that is what I believe.

12,531. So that you say the 20 gallons per head, which Mr. Latham ascribed to leakage, is really to be accounted for by water put into the sewers by the Bermondsey tanneries and by the inlets which are used for flushing the district sewers?—Yes.

12,532. (*Chairman.*) That shows, if correct, that Mr. Latham is wrong, but how does it affect the matter before us, I do not quite see; the sewers have to discharge this quantity of water, is not that so?—No, my lord, not quite so. In the first place, as regards the tanneries, I say that is a thing which ought to be checked and kept under control. As regards the flushing it does not take place in wet weather, which is the time when the capacity is required in the sewers.

12,533. He is speaking of a particular day?—A dry day upon which we got a gauging. Mr. Baldwin Latham made the remark that it was a very strange thing that we should have made gaugings of the flow at the time that they were flushing. Now that gauging was not made with any particular object except just to see, under ordinary circumstances, how the sewage came to our pumps, everything was left to go on as it did usually, and a record was taken to see what could be done.

12,534. (*Mr. Norman Bazalgette.*) Now I come to a very important allegation. At questions 7633–7, the allegation amounts to this, that the population provided for is already exceeded by half a million?—That was arrived at by taking the figures in the report of Messrs. Bidder, Hawksley, and Bazalgette, at page 41, where the population given upon the north side was 2,353,900, and upon the south side 1,094,600, making a total of 3,448,500. He deducts that sum from the population given by the Census 1881, namely on the north 2,548,999, on the south 1,283,488, making a total of 3,832,487, showing an excess in 1881 of 383,537, to which he adds 50,000 for the outlying districts, and for increase up to the present time 66,463, making a total increase of 500,000 people to this time, and I am disposed to adopt his figures. I do not think that they are far wrong, but in the capacity of the intercepting sewers provision has been made for double the average flow. Now double the flow is the same thing as the ordinary flow upon double the population, and that double flow was over estimated. We had not in designing the intercepting system made allowance for treating with so large an area. We treated it as if it had been a smaller area, and as if the maximum flow which takes place, say at about 10 o'clock in the day, produced the maximum flow in all parts of the system. But the fact is this; supposing the maximum flow to be at Bow, or Greenwich, at 10 o'clock, and to flow off to the outfall at the rate of a mile and a half an hour, that has flowed off long before the sewage from Bermondsey has come down to it. The sewage from Bermondsey has flowed away long before the sewage from the western district, and that has averaged or equalised the flow. Now from the gauging we took we found that the maximum flow instead of being double is only 40 per cent. more than the average flow.

12,535. (*Chairman.*) Do I understand you to say that this thing did not occur to you?—It did not. We said, when making our design, we will provide for such a population, we will provide for the maximum flow being double the ordinary flow, whereas we find that instead of being double it is only 40 per cent. more. Now the result of that is this, that assuming that the population at the present time to be as stated in Mr. Baldwin Latham's table, 3,975,468, and assuming the maximum flow to be 40 per cent. upon that, it would be equivalent to a population of 5,565,656, with a uniform flow; but the population actually provided for with a uniform flow is double what we provided for at the time of Messrs. Bidder, Hawksley, and Bazalgette's report, being 6,897,000, so that there is a balance of 1,331,344, supposing the flow to be equal, but making allowance for the additional 40 per cent. that gives really room for an additional population of 950,960, nearly 1,000,000; that is to say, with the 40 per cent. flow upon a total population of 4,926,400, or nearly 5,000,000.

12,536. (*Mr. Norman Bazalgette.*) That population, according to Mr. Latham's table, would be arrived at in the year 1896?—It would. I do not quite agree with Mr. Baldwin Latham's table as to the increase of population, for if you observe, London is getting filled up, and it will not increase. It is shown that it is not increasing as fast as it did formerly, but without picking holes in that, let us take it as it is stated, and that carries us to the year 1896, nearly the end of the present century.

*Sir J. W. Bazalgette. C.B.*

11 April 1883.

12,537. Now we will pass from Mr. Baldwin Latham, and I will put this to you; When you gave your evidence on the previous occasion, you stated in answer to question No. 9 that "It appeared from "tables of rainfall that there were only from 14 to "21 days in the year on which the rainfall exceeded "the rate of quarter of an inch in 24 hours; there- "fore we said, if we can divert the sewage from the "river in dry weather altogether on all those days "excepting the 14 to 21 according to the season (a "very wet season has been 30 days) we shall suffi- "ciently divert the sewage from the river to make it "clear." Mr. Symons disagrees with you. Will you tell me in what way you believe Mr. Symons' criticisms upon that answer were wrong?—In the first place Mr. Symons based his calculations upon years subsequent to 1856, when the rainfall has been, as he admits himself, excessive. Prior to that, the actual number of days which has been taken out upon which over a quarter of an inch of rain fell, was 25; but I was not speaking of rain falling, but of rain running off. My answer in the latter part of No. 9 shows that provision was made not for a quarter of an inch of rain falling, but for a quantity equal to a quarter of an inch running off. Now I wish to refer to the gaugings in Appendix No. 4 of the Report of Messrs. Bidder, Hawksley, and Bazalgette.

12,538. (*Mr. Abernethy.*) You provided for the quantity actually running out of the outlet?—Our provision is for the quantity running. I now draw attention to a table put in the Report of Messrs. Bidder, Hawksley, and Bazalgette, showing the gaugings of a sewer in Savoy Street. This shows that the quantity of rain flowing off in the case of the Savoy Street Sewer was 64½ per cent. of the total rainfall, this being a town area paved and built over. In a town area the quantity running off would be much greater than in fields where it would be absorbed.

12,539. (*Mr. Webster.*) That is running off in that time—in 36 hours is it not—not actually flowing off altogether?—Yes, "in the above-mentioned time," it is so. And in the case of the Ratcliff Highway Sewer, 48 per cent. of the total rainfall was run off; and the conclusion is "that the foregoing abstracts are of themselves conclusive evidence that the rainfall of 0·4 is not likely to yield of itself more than a quarter of an inch. So we say that to get a quarter of an inch running off through the sewers you look to the number of times in which 0·4 of an inch fell, and in that case you expect to get your quarter of an inch running in, and in excess of that to get an overflow. Now there were, on the average, only 12 days upon which more than that quantity fell. Mr. Symons' observations refer to the years 1877 to 1880 inclusive, in which years he admits in his answer to question 6956 there to have been a rainfall above the average He has divided the quarter of an inch of rain falling in 24 hours into the hundredth of an inch per hour and has assumed four-hundredths of an inch of rainfall each hour to represent the same thing as a quarter of an inch of rain running off the whole area in 24 hours. Now four-hundredths of an inch of rain falling for one or two hours in the day upon a dry surface, and in many cases upon a very small area, would really produce no discharge into the sewers at all. A quarter of an inch of rain running off in 24 hours is the same thing, and is equivalent to one-hundredth of an inch in an hour; so Mr. Symons said, I will take the number of days in which one-hundredth of an inch fell in an hour, as those are the days upon which your sewer would have been full. Now if you will look at that diagram (*handing a diagram to the Commission*); that upper line represents one-hundredth of an inch. Suppose that quantity to fall upon this road opposite to us, it would hardly make it damp; you would hardly perceive it; so that to assume that that would pour so much water into my sewer as to cause an overflow, is something than can hardly be realised; it is too absurd.

12,540. (*Chairman.*) I am not quite sure that I follow you, but there is no magic in hours. If an hundredth of an inch in an hour would do it, two-hundredths of an inch in half an hour would do it—according to that reasoning—not your reasoning, but according to the reasoning against you?—The reasoning there is that if a quarter of an inch running off in your sewers in 24 hours will fill those sewers, then one-hundredth of an inch, which is the same thing, for one hour falling upon a surface will fill your sewers too.

12,541. You deny that?—Yes.

12,542. I was venturing to help you by suggesting that if that argument is correct, then the two-hundredth of an inch falling in half an hour would fill your sewer?—Clearly.

12,543. And the four-hundredth of an inch in a quarter of an hour would fill your sewers?—Yes.

12,544. Whereas your argument is that it would not be sensible—that it would not be perceived at all—you might go still further and make it almost infinitesimal?—You might make it ludicrous almost.

12,545. You might say that a six-thousandth of an inch falling in one minute would fill your sewers, which of course it would not?—It would not affect them.

12,546. (*Mr. Norman Bazalgette.*) Now I believe you have taken 104 days in 1877, upon which Mr. Symons has said that 0·4 of an inch fell, and you have taken the number of hours during which the rain fell at that rate, and you have shown upon how many days that fall actually occurred?—I have.

12,547. Will you state to the Commission the way in which you have done that, and what the results are?—The figures Mr. Symons has put in show that in the year 1877 four one-hundredths of an inch or over fell in an hour upon 104 days, and the assumption as it stood was that upon those 104 days the sewers must have been full, and some overflow taken place. I have analysed that and I find that of those days, on 40 days that quantity fell for one hour only in the day; on 24 days it fell for two hours; on 16 days it fell for three hours; on 15 days it fell for four hours; on three days it fell for five hours; on five days it fell for six hours; and on one day for eight hours. If I add those hours all up together it reduces the 104 days to 10·37 days of 24 hours each in which the rain was actually falling.

12,548. I will just take it shortly, will you give the result for 1878?—The result for the year 1878 shows that out of the 82 days there were 32 days when the rain fell for one hour, 22 days when the rain fell for two hours, and that there were 14 days when the rain fell for three hours and so on, all of them show very much the same result. In the end they show that in 1878 there were actually eight days of 24 hours in which that quantity was falling, in 1879 there were 10·4 days, in 1880 there were 8·4 days, adopting the same principle. If you take the year 1879, there were 40 days upon which the rain lasted for one hour only, and 19 days on which it lasted for two hours, and then it continues decreasing for the longer periods.

12,549. Does it not follow from this, that but a few if any of the rainfalls which have been mentioned would have contributed to the sewers a quantity equivalent to a quarter of an inch running off in them from the whole metropolitan area at the same time?—Very few of them, the necessary periods would be reduced very considerably.

12,550. As the hours upon which the rain fell were not consecutive, would that have an effect in encouraging evaporation?—Yes; we find in many cases where it has fallen for two hours or three hours, that there have been dry periods between, it has fallen for an hour, or part of an hour, and then it has dried and evaporated, and then rain has fallen again. There is another point which I aught to allude to, and that is this, that these rainfalls are recorded at Kew. Now it does not at all follow that because that quantity of rain fell at Kew, it fell over the whole of the metropolis. On the contrary, the probability is that

it did not fall upon the whole of the metropolis, upon any single occasion. I have taken out a statement of the rainfall at Kew, and at Greenwich during the same days for several years, and I beg to hand it in, (*handing in a printed report*), it is very remarkable as showing that the two do not coincide I think in any instance. When you have had a heavy fall of rain at Kew, you have had little or none at Greenwich, and the table is really very instructive in that respect. It shows that there is the greatest inconsistency in the fall as one might expect. An ordinary rainfall does not cover 117 square miles, the rain cloud passes over from one end of the metropolis to the other, and it is discharging first at one hour in one part, and another hour in another part. There is another table at the end in which I have got out the number of days, and the number of hours per day in which 0·4 of an inch fell, worked out very carefully.

12,551. Does that also contain the number of days worked out in the same way in which one-tenth of an inch of rain fell in an hour?—It does.

12,552. You might just give us the sum of the results of that table as we have not yet had it, without giving us the details. I will put them to you. In 1877 the rainfall lasted at the rate of one-tenth of an inch per hour for two days upon the average equal to 48 hours in the year?—Yes, and in 1878 you have a rainfall for 2·8 days of 24 hours; in 1879 for $2\frac{1}{2}$ days for 24 hours, and in 1880 for $2\frac{1}{2}$ days.

12,553. I think you have said already that $\frac{1}{100}$th of an inch, or $\frac{4}{100}$ths of an inch falling in an hour in dry weather would scarcely do more than wet the surface?—It would, that is all.

12,444. Would it do about as much in the way of charging the streets with water as a water cart?—I should think not so much, a water cart throws it more heavily upon it, but it does not cover so large an area.

12,555. Having dealt with the theory of the thing, I believe you have some record of the number of times on which certain overflows which have been watched have actually occurred?—I have.

12,556. Will you give those to the Commission?—I undertook to give, as far as I could, the number of times of overflow; it is not an easy thing; in fact it is only possible in five cases, two upon the north side and three upon the south. We can only do it at our pumping stations, or where some one has been placed in charge and has been constantly there, and I put in a Table showing the results of those, and afterwards I will give some explanation with respect to them (*handing in the following Table*):—

STORM OVERFLOWS.

| Year. | Rainfall for the Year at Greenwich. | Deptford Creek. | Vauxhall P. S. Effra. | Battersea Creek P. S. Falcon. | River Lea, Old Ford. | Western Pumping Station, Pimlico. | | |
|---|---|---|---|---|---|---|---|---|
| | Inches. | Number of occasions of Overflow. | | | | | | |
| | | | | | | From Rain. | Special. | Together. |
| 1872 | 30·0 | 20 | — | — | — | — | — | — |
| 1873 | 23·4 | 16 | — | — | — | — | — | — |
| 1874 | 20·0 | 9 | — | — | — | — | — | — |
| 1875 | 27·3 | 20 | — | — | — | — | — | — |
| 1876 | 23·9 | 19 | — | — | — | Not known. | | 25 |
| 1877 | 26·8 | 30 | — | — | — | Not known. | | 53A |
| 1878 | 29·2 | 17 | — | — | — | Not known. | | 43B |
| 1879 | 31·3 | 21 | — | — | — | 36 | 12C | 48 |
| 1880 | 29·7 | 26 | 25 | 23 | — | 24 | 6 | 30 |
| 1881 | 25·2 | 37 | 19 | 18 | 22 | 12 | 6 | 18 |
| 1882 | 25·17 | 39 | 18 | 14 | 18 | 10 | 1 | 11 |
| Average per year | 26·40 | 23·09 | 20·66 | 18·33 | 20 | 20·5 | 6·25 | ·6 |

A. More than half the time for cleansing Isle of Dogs syphon.
B. Do. Do. and forming shafts.
C. Forming connections, &c.

The places are upon the south side, Deptford Creek, Vauxhall Pumping Station (the Effra), and Battersea (Falcon Brook). Upon the north side we have the river Lea, nearly opposite Deptford Creek, and the Western Pumping Station, at Pimlico.

12,557. The first column in the Table you have handed in, shows the rainfall for each of those years at Greenwich, does it not?—Yes, it does. You will observe that in 1881 and 1882 there is a very large increase in the times of overflow, and I will give you an explanation about that directly. At Vauxhall we only put up this pumping station in 1880, and therefore I cannot go back before that time. In 1880 there were 25 overflows; in 1881 there were 19, and in 1882 there were 18. At Battersea, in 1880, there were 23; in 1881 there were 18, and in 1882 there were 14. Then we come to the river Lea at Old Ford. I am sorry to say I have only two years of that; the man that we had there formerly did not write and kept no record; he died, and since then we have had another man who has kept a record. It shows that in 1881 there were 22 overflows, and in 1882 there were 18 overflows. Then at the Western Pumping Station, in 1876 there were 25, and in 1877 there were 53; more than half of those were pumping into the river during the cleansing of the Isle of Dogs branch and syphon. At that time we pumped into the river and did the same the following year; but we have since arranged, in order to cleanse a certain length of sewer, to put a board across the sewer and pump the sewage across that board into the other side of the sewer, so that it should flow, keeping the portion of the sewer you want to cleanse free of sewage so that you can get into it. Then, in 1878, we put in a number of shafts into the low level sewer to enable us to get in and cleanse it more easily than we could with fewer shafts, and that in the years 1877 and 1878 caused a large number of overflows. In 1879, which was a year of considerable rain, there being 31 inches of rain, out of the 48 days of overflows, on 12 of those days we were performing connections with the low level sewer, and diverting the sewage from the river, so that the actual days of pumping into the river were 36 for rain. In 1880 there were 24 days for rain and six days for making connexions or doing works in the sewers. In 1881 there were 12 days overflow for rain and six days for getting into the sewer, and in 1882 there were 10 days for rain, one for working in the sewer, making 11 in all.

12,558. (*Chairman.*) How is it that there would be four times as much overflow at Deptford Creek as there was at the Pimlico Pumping Station?—I am going to explain that.

12,559. (*Mr. Norman Bazlagette.*) Will you just state what the averages are for each of the overflows for the 10 years?—Taking all these things into consideration, the average overflows during the 10 years, including all these things has been, at Deptford, 23·09 times in the year; at Vauxhall, 20·66, or $20\frac{1}{3}$ times; at Battersea, 18·33; at the river Lea, 20; and at the Western Pumping Station, for rain, $20\frac{1}{4}$, and for other purposes $6\frac{1}{4}$.

12,560. Is the average of all of them taken together 19·66?—I have not averaged it.

12,561. (*Chairman.*) Of course, upon these occasions the whole of the overflow is not sewage, nor is it rain; could you at all tell what per-centage of sewage went over and overflowed; you could not tell, I suppose?—No, it would vary so much with different rains.

12,562. Some of these overflows, I suppose, may have had an almost inappreciable effect upon the water of the river?—Where there is a very heavy fall of rain and it is continuous, it would have a very slight effect; it would be very highly diluted.

12,563. I suppose you may say that if the rainfall is small the overflow is small, and if the rainfall is large the overflow is large but is much diluted?—Yes, precisely.

*Sir J. W. Bazalgette, C.B.*

11 April 1883.

12,564. (*Mr. Norman Bazalgette.*) I see at question No. 9, when you gave evidence first, you said that when you were considering the main drainage system, you estimated there were from 14 to 21 days in the year when the storm overflows would come into action?—Yes, and in a wet season I should think it might rise from 20 to 30.

12,565. Referring to the Tables I see that the overflows range from 18 times to 23?—Yes, if you take it for rain alone. Now I wish to explain how it is that in the years 1881 and 1882 you get that excessive discharge at Deptford Creek, which the Table shows. This (*producing the same*), is a model which we had prepared for a trial which arose, which I am going to explain to you. This represents the high level sewer, coming down to Deptford Creek; the sewage under ordinary circumstances falls through this grating at the bottom of the sewer and passes into three iron pipes, which carry it underneath the creek into the outfall sewer, and it is so arranged that when the sewage flows into this sewer up to the height of the lower gate, it is discharging the calculated maximum quantity of sewage for the district. When it rises above that quantity and this flap opens, it flows over and into the creek; but it was found that this flap, in times of heavy rain, did not let off a sufficient quantity, that is to say, did not let it out of the sewer fast enough. So what is done is that a sluice keeper is kept there, and he lets go this fastening and discharges the whole contents of the sewer into the creek for the time being. Now in doing that (it is a narrow creek and there is a wharf opposite it) on one occasion it burst out with such force that it blew away the wharf wall opposite to it; it undermined the wall and that gave rise to an action.

12,566. That happened in the month of August 1879, and the action was in 1880?—The upshot of it was that the flapkeeper received instructions, "When "you find that the barometer is falling, and there is "an appearance of rain, and that the sewage is rising "very fast in the sewer, do not wait till it rises to the "top of the outfall, but let it go before, so that it "shall not go out with such force." He has acted up to his instructions, and has let it go rather more often than we expected; he has taken care of himself, no doubt quite rightly, but the result has been that he has let it go more frequently than we expected. We are now constructing a new outlet behind this sewer into the Thames itself, instead of into the creek; as soon as that is finished, there would be no necessity to do this any more, and the overflow will return again. I have no doubt, to the quantity at which it had previously stood, from 9 to 30 days.

12,567. Now, to pass from the storm overflows to the reservoir, what was the object of fixing the lowest part of the reservoir at 2·75 feet above ordnance datum?—The object was not to discharge the whole of the sewage at one time, but to discharge it over a period of 2½ hours; that was the original intention.

12,568. Why over a period of 2½ hours?—Taking about half the tide, not to discharge it immediately at high water, but so as to have it not all in one mass; it was considered better to let it go down the river and partial return than to pour it out all in one mass at high water; that it would become purified by the admixture with the Thames water, and would not return in the form of sewage.

12,569. (*Chairman.*) In order to do that, you did what?—We placed the bottom of the reservoir at the level to which the tide falls upon the average in 2 hours 40 minutes. The overflow weir is about 5 feet 6 inches above high water, so that when we open the sluices at high water there is first a very large discharge from the reservoir—it empties itself rapidly. Then, having come down nearer to the tide, it discharges itself more slowly as the tide falls, and is completely emptied in 2 hours 40 minutes. That is shown by Mr. Baldwin Latham's diagram of the tides. We call it 2½ hours, he makes it 2 hours and 40 minutes.

12,570. In 2 hours and 40 minutes the contents of the reservoir are emptied?—In 2 hours and 40 minutes after high water the tide has fallen to the level of the bottom of the reservoir, and therefore the sewage has flowed into the river, the reservoir having emptied itself.

12,571. But it will flow into the river after that, will it not?—If we keep the gates open all that has come in will flow out; as a matter of fact, we have kept the gates open a longer time, and have discharged four hours after high water; but that is because, as I have described, our reservoirs were too small.

12,572. If your reservoirs were larger, and you could discharge upon the first half of the tide, you would have less return to you?—If our reservoir were large enough, and we could manage it, we should close it 2 hours and 40 minutes after high water, instead of going on, as now, for four hours.

12,573. The consequence of which would be that you would have less return to you?—Yes, that is so.

12,574. But you said it was, you thought, objectionable to discharge such a great quantity all at once; why do you think so?—I think it better not to pour so large a mass into the river at one moment, but to give it a couple of hours time to flow off.

12,575. If you could let it off in the first half hour, the vessels about there would be in truth in a flood of sewage, and nothing else; would not that be so?—No, I do not think it would reach the middle of a river; it would make a larger mass, of course.

12,576. (*Mr. Norman Bazalgette.*) I believe, as a matter of fact, about one half of the contents of the reservoir is discharged upon the first hour of the ebb?—About 5 feet 6 inches.

12,577. And the remainder in the next hour and a half?—Yes.

12,578. I may, just to clear up this point, while I am upon the subject of reservoirs, ask you is it the fact that the reservoirs of the main drainage system were designed with a view of carrying out any chemical process or deodorization in them?—No, they were not. I may also say that the reservoirs are in this respect unlike the rest of the main drainage system; there would have been no object in making them, in the first place, large enough for the future population, because they can be added to now, and they can be added to 10 years hence, and it would have been a waste of money to build them at the present time of the size which will be required 30 years hence.

12,579. You told me when you were first examined that the Board of Works have, as a matter of fact, actually let the contract for enlarging the reservoirs, and are only awaiting the result of this inquiry to proceed with the work?—Yes, the work would have been in hand a year ago, but the Board determined to await the result of this inquiry. I think I have mentioned that the Board are now carrying out works for the getting rid of storm water more rapidly, and preventing flooding, the estimated cost of which is a million and a half, of which half a million is now in hand—one-third is in hand and the other two-thirds have yet to be carried out, and that two-thirds includes two sums for enlarging the reservoirs, 60,000*l.* for the southern reservoir, and 150,000*l.* for enlarging the northern reservoir.

12,580. Captain Burstal told us he took certain float observations in 1866, will you tell the Commission shortly what part you took in those observations, if any?—Captain Burstal received instructions from the Government to make float observations, and to test the original observations, and I received instructions from the Metropolitan Commissioners of Sewers to make them in concert with him, and though we did not ourselves follow the floats up and down, we met and arranged matters in concert.

12,581. You supervised the movements of the floats and checked the results, though you did not follow the floats yourself?—That is so.

12,582. When and for what purpose was the system of catch-pits introduced in London?—The system of catch-pits was introduced for the purpose of preventing deposit from getting into the sewers, that is say, the

road detritus and the heavier matter, and it has been very successful in doing so.

12,583. Can you give the Commission any idea of the quantity of road detritus which has been intercepted by these catch-pits in any given year?—I can. There are 775,000 cubic yards per annum removed from the streets.

12,548. A cubic yard is about equal to a ton?—Yes. Of that quantity 616,500 are removed by scavenging by carts, 133,000 tons are removed from the catch pits, the catch pits are placed by the side of the road to catch the heavy detritus and let the water flow over it, to prevent it going into the sewers, and 25,600 cubic yards are removed from the sewers. (I am taking the figures for the year 1878), so that the great bulk is removed from the surface, and then a large quantity from the catch pits, and a smaller quantity from the sewers themselves. There is a direct interest to us in doing that, inasmuch as it is very much more costly to get it out of the sewer than it is to get it out of the catch pits, and more costly to get it out of the catch pits, than to get it off the roads. I may say that of those quantities as nearly as we can estimate about 40 per cent. is road detritus, 40 per cent. is water, and 20 per cent. is garbage from the markets, and refuse.

12,585. Br. Frankland told us that he did not think the operation of these catch pits was efficient; what do you say to that. I presume the quantities you have given us are your answer to that?—They are efficient if they are properly looked after, if they are neglected and allowed to get full, they cease to operate, but if they are emptied from time to time they answer very well.

12,586. (*Chairman.*) But sewage would not get by that means into the river, it would only be the washings of the streets?—no, the sewage would not, it would only be the deposit of the roads and the manure droppings in the streets.

12,587. (*Mr. Norman Bazalgette.*) Would a sample of sewage taken at the outfalls, before the system of catch pits was introduced, afford in your judgment a fair criterion of the amount of suspended matter delivered at the outfalls after the system of catch pits was introduced?—Certainly not.

Cross-examined by Mr. Webster.

12,588. My learned friend Mr. Bazalgette has suggested to you that a comparison between the two samples would be fallacious. When do you say the catch pits were introduced?—I do not remember at the moment, but it was stated in my evidence before the last Commission.

12,589. (*Chairman.*) You cannot tell us anything about the mud banks and smells, or anything of that kinds?—No, I cannot.

(*Mr. Norman Bazalgette.*) The Corporation have called five or six engineers, all of whom have made different parts of the Corporation case, and Sir Joseph Bazalgette has confined his evidence to the drainage system.

12,590. (*Mr. Webster.*) A little speech has been made by my learned friend Mr. Bazalgette as to whether a particular comparison would or would not be reliable. I wish to know when this catch pit system was introduced, I am informed it was in 1846?—I will endeavour to get it as correctly as I can, but it would be dangerous to give you any particular date, it began to be used at one time and then its use increased in subsequent years.

12,591. Could you give us the number of catch pits at any intervals of years, say in 1870, and in 1880, and so on, because the mere general observation as to a sample before catch pits, and a sample after catch pits might be a truism; but I want to see what the figures are?—I beg to read my answer upon a former occasion in the Mud Inquiry. "It would be difficult "to say when they were first made some 30 years ago "there were very few of them, and they were of very "defective construction, that is to say, they were "mere pits which would receive the road detritus, and "when it rose to the level of the overflow, a good deal "of the detritus would go into the overflow sewer "and pass away." Then I say "about 30 years ago "considerable attention was paid to the subject of "forming catch pits," and that "since then they "have been very much improved and very largely "extended."

12,592. What date is that?—1880.

12,293. That takes us back to the year 1850, it refers to a time when the catch pits were largely extended and an improved kind of catch pit was introduced?—It is about 30 years ago.

12,594. Upon this question would you give us, if it is of any value at all for the purpose of comparison, the difference in the number of catch-pits at any epochs which you could pick out for yourself?—I do not think I could.

12,595. There is information upon the point is there not?—I cannot give you any information as to the number, because they were in the hands of so many vestries and district boards.

12,596. You have said that this enables you in some way to form a judgment upon the amount of detritus which goes into the river and that which does not. All you have given is the total quantity of detritus, which you have taken as 775,000 cubic yards, which you divide into three quantities, 616,500 removed by scavengering and carts, 133,000 from the catch-pits, and the balance 25,600 taken out of the sewers?—Yes.

12,597. That does not take any notice at all of what may have gone out along with the sewage?—It does not.

12,598. Therefore except that it tells us that so many tons are taken in those three ways, it does not give us any information at all?—It simply shows that this detritus did go into the river until it was intercepted.

12,599. Does the 25,600 go through the catch-pits?—Yes, it does.

12,600. That is something which the catch-pits will not intercept?—Yes.

12,601. Have you made any estimate at all of what the total road detritus due to the whole surface area of the streets is.

(*Chairman.*) You mean for the metropolis.

12,602. (*Mr. Webster.*) Can you tell us at all what does go out into the river and is not taken out of the sewers, because you have given us what was taken away in carts, and what was taken away from the catch-pits, and what was taken out of the sewers. I want to know if you have any estimate of what goes through the sewers?—Yes, we have made an estimate. What I understand you to want is the total quantity put on to the roads.

12,603. You shall give it me in any way you like. I only want the facts; you have only given to me those three figures, but those three figures you have given do not exhaust the question, because they simply give what is taken by carts, what out of the catch-pits, and what out of the sewers, are you able to give us what the balance of the road detritus is which passes through the storm outlets or the sewers?—I cannot give it you here, but it is a small quantity, I can tell you that.

(*Chairman.*) (*To Mr. Webster.*) Do not suppose I am finding fault with you, but I do not understand. Suppose Sir Joseph were to tell you that there was as much more unaccounted for or half as much more, what then?

(*Mr. Webster.*) In the first place it does contain, I will not say so much matter, but more or less offensive matter, there is no doubt it does contain, as Sir Joseph told us, the dung of the streets and other things which tend to produce noxious matter, but the important question is what is the specific gravity of the sewage which naturally comes out, and I wanted to know

*Sir J. W. Bazalgette, C.B.*

11 April 1883.

whether Sir Joseph meant to say that no detritus at all went out into the river, and if any did, what did, the three figures do not exhaust the whole question.

(*Chairman.*) The rest goes through the sewers, and is an element or portion of the offensive matter.

(*Mr. Webster.*) It is an element which must be considered.

(*Chairman.*) Is that so.

(*Mr. Webster.*) To a greater or less extent. I want the figures to be complete.

(*Witness.*) In the year 1878 there were 1,338 miles of macadamised roads, 274 miles of paved roads, 61 miles of paved courts, 22 miles of asphalte, and 15 of wood paving, making in all 1,710 miles of roads, and upon those roads were put in the year 1878, 307,700 tons of macadam flint or hoggin, and in addition to that I estimated that off the granite paved roads another 39 tons were probably worn away in the course of the year.

12,604. (*Mr. Webster.*) Is that all?—Yes.

12,605. You have spoken of 775,000 cubic yards, and you told my learned friend, Mr. Bazalgette, that a yard was equivalent to a ton?—Yes.

12,606. What you have given there as being put on is not half that?—No.

12,607. What would the rest be made up of?—The rest would be made up of 40 per cent. of water, 20 per cent. of garbage, and the refuse of markets, houses, and streets.

12,608. What you have given me is not what I asked for, which was not an estimate of the amount of granite or hoggin put on and worn away, but what the total amount of road detritus, water, and garbage was for the corresponding year for which these figures have been given. You said, I think, that you had an estimate somewhere or other of what the total quantity would be, showing the balance beyond the 775,000 cubic yards which does go into the river or disappears somewhere else?—No, I think I have given you all the figures I have.

12,609. Are you unable to tell us what you estimate to be the quantity of detritus that passes into the sewers?—I am unable to do so.

12,610. Do I understand that you have not considered this question of the effect of the present mode of dealing with the Metropolitan sewage; as you have not given evidence about it, do I understand that you have not considered it?—I have considered it.

12,611. Speaking generally, you do not deny, I presume, that there is a washing backwards and forwards of the sewage for a certain period, between, we will say, 10 miles, or I should think I might put it at 15 miles, or I will say 5 miles above and 10 miles below the middle point of Barking and Crossness?—I cannot speak to figures.

12,612. I said "speaking generally"?—I cannot speak to figures, because I did not conduct the experiments.

12,613. Forgive me for bothering you about the matter, but you have been with the Board for many years, and have considered this matter more than most people, I suppose; it is not an incorrect statement to make, is it, subject to what more accurate examination may show, that there is a washing backwards and forwards of the sewage from a distance of 10 miles below what I may call the middle point to five miles above?—Theoretically, supposing the sewage to remain unchanged, that is so.

12,614. I will come to that directly; have you in past years investigated the distance to which that oscillation takes place?—Yes.

12,615. When did you first investigate it?—When the float experiments were made.

12,616. When was that?—I think it was in 1856.

12,617. Will you tell us now if you recollect what conclusions you came to as to the length of distance, in the first place, that this carrying backwards and forwards was spread over?—Yes, about 12 miles from high water to low water.

12,618. Have you altered your opinion since with regard to that question of distance?—No.

12,619. Do you think it is about right?—I think that a float put in about high water would go down for about 12 miles and return again.

12,620. I was not dealing with the float. I was asking you the area over which you think the sewage would oscillate?—I did not enter into that question at all.

12,621. I have not much curiosity about a bit of wood floating up and down the river. I am here upon another subject altogether. I want to know whether at any time during the last 30 years you have formed an opinion as to the distance over which the sewage would oscillate?—No, I cannot say that I have.

12,622. At no time?—No.

12,623. (*Chairman.*) I thought you said 12 miles would be the distance it would travel upon a tide?—But Mr. Webster objects to my taking a float as representing the sewage.

12,624. I understand the effect of Mr. Webster's question is, supposing the sewage did not get mixed but continued to float up and down the river?—I considered that if it did not get mixed it would float down about that number of miles; that with a spring tide it would rise higher up the river, and that with a neap tide it would go further down.

12,625. (*Mr. Webster.*) As a mere question of floating, you consider it would probably be driven backwards and forwards over a distance of 12 miles?—Yes, I do.

12,626. Quite apart from chemical action, did you ever form an opinion as to during what period the oscillation would take place over that range before the sewage was carried out?—No, I never went into the question of what the sewage would do.

12,627. I want to put this to you. I am not dealing with the question of the capacity of your outfall, or the size of the sewers, or anything of the kind at the present moment. Had you formed no theory before the construction of these works as to the time within which the sewage would disappear and go to sea?—No, I have not. I believed that it would never go to sea in the form of sewage.

12,628. I am not going to suggest that when I use the word "sewage" it is to avoid the necessity of putting in every question the words "sewage which has been subject to chemical action." However, you did not form an opinion as to what period it would get to sea and never come back again?—I cannot say that exactly, because I was obliged to take into consideration the evidence afforded by the floats.

12,629. Do you agree with the evidence suggested by the Corporation as to the length of time in which the sewage, altered or unaltered, floats backwards and forwards before it reaches the sea?—I should not like to express an opinion upon that subject.

12,630. Did you form an opinion upon that subject at any period before the year 1870?—Yes, I did.

12,631. What did you assume then was the period during which, or over which, this oscillating action might take place, as distinguished from the space in which it would take place?—Again I am unable to answer that question, unless you permit my reference to the solid body unchanged.

12,632. Now have you formed any opinion yourself, from your experience, as to the effect of any chemical action, either dilution or oxidation?—I had formed an opinion that the dilution and the oxidation would destroy the sewage rapidly after its discharge into the Thames.

12,633. I would ask you first when you formed that opinion?—I formed that opinion before I designed the main drainage.

12,634. Was that the result of experiments made by yourself?—It was the result of general observation.

12,635. Pardon me, was it the result of experiments made?—No, not of any special experiments.

12,636. Is it embodied in any report?—It is embodied in several reports.

12,637. I should like you to tell me, if you c of any report in which you have dealt with the question of dilution and oxidation prior to this Commission?—I will ask leave to produce them by-and-bye.

(*Chairman.*) (*To Mr. Webster.*) Is the object of this to show that Sir Joseph Bazalgette designed this great work without contemplating what mischief he would do.

(*Mr. Webster.*) I merely meant this. I wished to suggest that it was not known what would be the effect of this large mass of sewage. I am exceedingly anxious not to appear here in any way on behalf of the City, as attacking the Metropolitan Board of Works in the slightest way. I am only here for the purpose of getting at the facts.

12,638. (*Chairman to the witness.*) How is that? Had you before you designed this work speculated upon what would be the effect of it, and whether the mixture and oxidation would have between them some effect, and what effect?—I had taken a good deal of trouble to inquire into the matter during the time I was designing the system. I had before me the effect of the sewage poured in at low water at London, and the effect at high water when diluted by a large body of water. I also went with Messrs. Bidder and Hawksley round to Manchester, Birmingham, and other towns to see the effect of putting sewage into their rivers, and to trace the sewage down a certain distance to see at what points it became destroyed and lost, and how soon the rivers purified themselves. So I took a great deal of trouble and care to look into the question before we fixed upon these points of outfall, and I think I shall be able to produce some reports in which I brought that out.

12,639. (*Mr. Webster.*) Of course I have only what is before me at the present time; what I want to know is this,—if you wish to postpone the answer until you can get the reports, by all means do so,—I want to know if the effect of oxidation was taken into account by you as a distinct integer which would counteract the otherwise injurious action after the sewage got into the river?—It was.

12,640. What was the value put upon that action or agent for the purpose of avoiding possible nuisance; to what extent was it supposed it would act?—I do not suppose I can give it you in figures.

12,641. Neither with regard to time nor volume nor anything else?—I have no doubt that at the time those elements were entered into very fully, but I have no record of it before me now. My attention is called now to a report by Dr. Letheby to us at that time, who had considered the matter very fully.

12,642. If you can refer to any reports either now or afterwards, will you do so?—Yes, I will do so afterwards.

12,643. It amounts to this, that generally the possibility of oxidation assisting to deodorise the sewage would have been taken into consideration?—It was.

12,644. But to what extent it would operate you do not recollect; whether it was put down as a question of time or volume?—It was both.

12,645. I know, in general terms; but taking the volume you had to deal with, to what extent?—Speaking from this distance of time, I cannot give you the figures.

12,646. Of course a small drain turned into a comparatively small stream may get oxidised, and not do much harm in consequence. On the other hand, if you had a much larger volume of sewage going into the same water, it would take a much longer time to oxidise?—We went into it in that way.

12,647. And having gone into it in that way, I should be glad to see any report which would embody the effect of your inspection. Did you at all deal with the question of the solid matter? I have no doubt you did?—We did.

12,648. Did you form an opinion as to what were the solid constituent parts of the sewage going into the Thames?—Yes.

12,649. Do you remember what that was?—I do not.

12,650. Has that changed, or are you assuming that the figures you have calculated are correct?—I cannot recollect what those figures were.

12,651. And you cannot tell me whether your present judgment has caused you to deviate from those figures at all?—I do not recollect.

12,652. It was imagined, was it not, that although theoretically there would be this floating backwards and forwards, yet to a great extent the sewage would be carried direct out to sea?—I do not think so; not as sewage.

12,653. You say "as sewage," I say carried out to sea so as not to remain in the water in any way noxious. Perhaps I ought to put this to you; besides the oxidation which is largely mixed up with the dilution, was there any other chemical action that you relied upon, or that you thought was an assistant?—No, I think not.

12,654. It was thought to a great extent that you had gone so far down, that there would be, comparatively speaking, a short period in which noxious sewage would remain in the river?—Yes.

12,655. Were you one of those who thought you need not have gone as low as Barking?—No, I always recommended Barking.

12,656. There wers others, were there not, who thought that Barking was too low at that time. I have a recollection of reading that in some of the reports?—I have heard it so stated, but I do not remember it.

12,657. The importance of the lower reaches of the Thames, from a port point of view, is increasing every year. I am referring to the fact of vessels passing through it, and the increased trade coming to the Thames; therefore, from a sanitary point of view, you would admit that the lower reaches are much more important now than they were 20 years ago?—Yes.

12,658. The main and pressing question you had to deal with at that time was that the Thames was a nuisance under the noses of the people living in London?—It was.

12,659. And you would not deny, I presume, that if the same thing, though not to the same extent, was growing up again in these lower reaches, that would be a serious evil?

(*Chairman.*) Is Sir Joseph an expert upon this question? He is a gentleman whose opinion I should be glad to have on anything, even upon an astronomical question; I have no doubt he would be able to instruct us, but do you think it is necessary to put this question to him?

(*Mr. Webster.*) The idea was, before the date of the discussion as to the outfall, that the sewage should not be returned to the metropolitan area. It may be (but I do not think the Commission would come to that conclusion), that they have fulfilled, or still do fulfil, the letter of the restriction existing or proposed, or wished to be arrived at at that time, namely, that the sewage should not be permitted to flow back into the metropolitan area, but there may be the same nuisance growing up to the lower reaches of the river, and what I wanted to get at was whether Sir Joseph Bazalgette considered that if that was the state of things——

(*Chairman.*) It would take less time to ask him the question than to discuss it, because he is a gentleman whose opinion we should be glad to have upon anything.

12,660. (*Mr. Webster.*) Assuming that there is growing up, as I have said lower down in the river, that which will become a nuisance especially in hot weather from the smell, and the condition of the water. do you consider that that is a thing which must be borne with and not corrected by taking the outfalls elsewhere?—If you begin by assuming that there is a nuisance.

12,661. Growing, I do not say actually existing at the present time, but growing up?—If there is a

*Sir J. W. Bazalgette, C.B.*

11 April 1883.

nuisance it should be removed, but I do not admit that there is a nuisance.

12,662. Is it your opinion that the nuisance in the Thames in the old times was solely due to the water, that it arose entirely from the sewage in the water? —Yes, I think so, in the water and upon the banks.

12,663. I was coming to that, do not you think it arose to a very considerable extent from the sewage deposited at the bottom of the river and upon the banks giving off gases?—I think it did.

12,664. It is your opinion, is it not that this nuisance from the soil upon the bottom of the river and upon the banks was not the result of a merely temporary deposit but was aggravated by the length of time that the deposit had remained there?—I daresay it was.

12,665. I mean that a sewage bank, or a bank that would be affected by sewage mud is not of necessity the result of the growth of a couple of months; it may take much longer to grow up?—It would take some time to go if it is of any extent.

12,666. Have you yourself ever examined the question in hot weather of the existence of smells in the water?—No; I am, fortunately or unfortunately, a bad person to judge of that; my sense of smell is not very quick, and I should not detect it rapidly.

12,667. I am not now dealing with an expert's analysis of the water of the present time or last year, but I want to ask you if any person is coming who will give us actual evidence as to the condition of the water in the last five, or six, or seven years?—Yes, there is.

12,668. Now will you give us, in the shape of a table, or somehow or other, how often or over what period sewage has been discharged from the high level and the tower level, that is to say, from the northern and the southern outfalls respectively, after high water? —We have discharged up to four hours after high water, and sometimes we have been obliged to discharge before the beginning of ebb tide, that is to say in a flood when you have heavy rains.

12,669. I am afraid I want it a little more in detail, if you will give it me. I presume a record is kept of the discharge?—Yes.

12,670. There can be no difficulty in putting in a tabulated statement for, say, the last eight years, the hours of the outpouring or letting out of the sewage upon the north side and the south side respectively?— I do not think there would be any difficulty about that.

12,671. Would you also kindly show upon that table the instances in which it began before high water, and of course the duration of it; in all other cases I presume it began at high water?—Yes.

12,672. What did you contemplate as being the time which would be required for emptying the reservoirs?—Our reservoir is arranged for emptying itself in 2 hours and 40 minutes after high water.

12,673. You can open when you like, because I understand if it is anything like full, there is always sufficient head to enable the sewage to run out even upon the top of the highest tide, is that not so?—Not all of it.

12,674. I did not say "all of it." I spoke of commencing to discharge. I assume you do not turn out the sewage before high water unless you have a pressure of sewage in the reservoir?—That is so.

12,675. In an ordinary high tide, how much below high water mark is your sill, you say it is designed to run for 2½ hours?—It is 8 feet below mean high water.

12,676. (*Sir John Coode.*) Is that the mean of spring and neap?—Yes.

12,677. (*Mr. Webster.*) And the tide falls, roughly, that 8 feet in 2 hours and 40 minutes?—Yes.

12,678. When the reservoir is full, what depth of water is there above the 8 feet sill?—13 feet; 13 feet 5 inches is the depth of the reservoir.

12,679. It amounts to this, therefore, that you have a head of somewhere about 5 feet which will run off even when the water is at the ordinary high water mark?—Yes.

12,680. You can of course continue the discharge as long as you like until the tide comes back again? —Yes.

12,681. And it will be the necessities of the supply of the sewage and rain water mixed together which would regulate how long the outfall was opened upon the one day or the other?—Yes.

12,632. You had better give us the same information for the southern outfall, if there is any difference? —There is very little difference, the southern outfall is rather deeper, and therefore there is a greater head upon the south side, it is 2 feet higher, the bottom is the same level, and it is 2 feet 6 inches deeper.

12,683. Is the bottom of the sill 8 feet below ordinary high water mark?—Yes.

12,684. But it is 15 feet 6 inches deep instead of 13 feet, is it not?—Yes.

12,685. Now, I will ask you a question or two about some of the things you have said to-day, with regard to the question of capacity. I am afraid I do not quite understand about the double flow, you made the sewers for double the maximum flow, I understand?—For double the average flow.

12,686. You made them for double the average flow of an assumed population for the day, that is so? —Yes.

12,687. And that without rain?—Yes, first; that is the first part of it, then we made provision for the rain in size.

12,688. The first estimate you dealt with was the sewage?—Yes.

12,689. You said to-day that the first thing you did was to assume double the population. Having got the estimated flow of the existing population, then you doubled it; is that correct?—No. What I stated was this, we took an assumed future population with an average flow of 31 gallons per head, then we said we will provide for double that quantity.

12,690. That is 62 gallons. It would either be double the population or double the flow from the same population?—Yes.

12,691. Now what did you add on besides that?— We added on a quarter of an inch of rain. I am reminded that with regard to some of the outlying districts we added only an eighth of an inch of rain.

(*Sir John Coode.*) Can you tell us what proportion one district would bear to the other, that is to say, the area for which you allowed a quarter of an inch compared to that for which you allowed an eighth of an inch of rain?

12,692. (*Mr. Webster.*) I think I can get it in answer to this question. First, I understand you to say that you adopt now the figures which Mr. Baldwin Latham gave of the population, namely, 3,832,441?—Yes.

12,693. Could you put your hand upon the figure of the population which you did actually take?—It was 3,448,500.

12,694. Will you kindly divide that into north and south?—North, 2,353,900——

12,695. But you are here reading off Mr. Baldwin Latham's figures?—No, I am now reading the quantity provided for by Messrs. Bidder, Hawksley, and Bazalgette.

12,696. You are quoting from the same report as was quoted by Mr. Baldwin Latham?—Yes.

12,697. Those are the figures upon which you acted?—Yes.

12,698. Having got that, taking your 31 gallons (which I presume you take the same on both sides as the ordinary flow)?—We did.

12,699. What did that come to? Have you got the figures there?—No, I have not got the figures here.

12,700. Now I want you to answer what Sir John Coode put to you, because it was a matter I was just going to put to you myself. Will you tell us, as nearly as you can, either in distances or sewers, where you allowed for the quantity of a quarter of an inch

of rainfall and where you allowed for one-eighth?—I will put it all in full for you.

12,701. Did you always allow as much as an eighth?—Yes.

12,702. I do not understand why you say the increase now is only 40 per cent. Would you just explain that to me again. I dare say the members of the Commission followed it. You say now experience shows that instead of estimating for a double flow you need only have estimated for an increase of 40 per cent. Do you mean that an increase of double the population would be only equal to 40 per cent.?

(*Chairman.*) The way I understood it was this, that he thought the sewage, instead of flowing at an average equal rate, would at one period of the 24 hours be double the average, and, therefore, he arranged for double what would be required if it were all flowing at the same rate in 24 hours; but he says, experience tells us that the maximum flow is only 40 per cent. above the average, and, therefore, he says, we have fortunately got a much larger discharging power than we should have had if we had known the truth.

(*Mr. Webster.*) That assumed the population remaining constant.

(*Chairman.*) Then he says, the population not remaining constant, I add the increase of population to my 40 per cent., and get to the conclusion that still I have more than enough.

12,703. (*Mr. Webster.*) Do I understand you to say that experience shows that the maximum flow is never more than 40 per cent. above the average?—The only actual experiment I have is that which was made at Crossness.

12,704. When was that experiment made?—The experiment to which Mr. Baldwin Latham has referred many times was made on the 12th July 1876; it shows at different hours of the day the quantity flowing off, commencing at 1 in the morning and continuing till 12 at night.

12,705. Do I understand you to say that your evidence about finding that 40 per cent. is the increase or excess above the average flow, is based upon that experiment only?—That is so.

12,706. You have no experiment with regard to the northern outfall at all?—We have not; we had not the means of doing that.

12,707. Do I understand you to say that from any data you can give us on the northern side, it never flows more than 40 per cent. as the maximum above the average which the population would show?—I cannot say that; we can only judge by what we have got.

12,708. Now I would like to ask you this. The south would be no criterion for the north for that purpose, would it?—Yes, I think it would.

12,709. You have got, according to you, 16 gallons per head per day, and we say more, which is due to exceptional circumstances; it is 16 out of 50 or 16,000,000 gallons, which is due to exceptional circumstances?—Yes.

12,710. The experience of other places is, is it not, that there are hours of the day when the flow varies much more than 40 per cent. above the average?—Yes, and that is our experience too. I explained in my evidence in chief why it was that when you are dealing with a large area, it necessarily reduces the rate of flow to a more uniform rate.

12,711. That is just what I was coming to. I want to get at this,—what data have you upon the north side of the Thames for saying that the maximum flow in any given 24 hours is never more than 40 per cent. above the average?—I can only say, from the experiments I have made upon the south side, which I believe to be under the same conditions as the north, that that is what I find to be the case, subject possibly to some variation, owing to water being let in from the Thames, which might have made it somewhat worse or somewhat better.

12,712. In the first place, I have already pointed out that that is one experiment only, and that is based upon what was flowing when there were 50 gallons a head flowing through as against 31 gallons of ordinary sewage. I do not see how the fluctuations in the 24 hours, when that exceptional flow of water was going through upon the south side, would be any criterion from which you would say as an engineer that the flow of sewage upon the northern side would never rise in any part of the 24 hours more than 40 per cent. beyond the average?—I think the tendency would be upon the south side to increase the maximum flow.

12,713. The tan yards counted for 25 per cent., you think, of this extra water?—Yes.

12,714. How do you get any information at all as to the mode of dividing it out into one quarter to the parishes, one quarter for yourselves, one quarter leakage, and so on?—I cannot get it any nearer than that.

12,715. Now, taking the question of rainfall, are we to judge of this by the eye. Do you ask us to look at this thin strip (*pointing to a diagram*) and ask us to consider that quantity falling and flushing the sewers at all?—Yes.

12,716. In what period is that supposed to fall?—In an hour.

12,717. Would the next strip flush the sewers?—If falling for an hour, it would probably contribute something to it.

12,718. You have had such things as flooding the sewers, have you not?—Undoubtedly, we have had as much as 2 inches of rainfall in an hour.

12,719. That is not quite the point; what I want to know is what from actual experience you find has been the effect, do you not find that a much smaller quantity of rain falling than this thick line, that is, the tenth of an inch, will cause flooding?—No, certainly not.

12,720. Do you remember the correspondence between the vestry of Paddington and the Metropolitan Board of Works in August 1878?—No, I do not.

12,721. Do you remember that the sewers were rising, so that building operations had to be stopped?—Yes, at Paddington.

12,722. Do you remember the quantity of rain that fell?—Yes, it was something very heavy.

12,723. Have you a record of it?—Yes, I have, but not here.

12,724. Would you mind bringing us that here upon the next occasion?—You are referring, I presume, to Mr. Whitehead's premises?

12,725. I am referring to the correspondence between the vestry of Paddington and your Board in August 1878, you reported upon that?—I do not remember what the report is, but I will look it up and see what it is.

12,726. While I am upon that, I want to ask you this: what opportunity, or have you any means of telling what was happening at the other storm outlets at any period of time?—No, I have given you all of which I have any record.

12,727. How many storm outlets are there?—I have stated it in my evidence-in-chief.

12,728. All those red dots upon the map are storm outlets?—They are. I beg to hand in a list of them.

*The following list was handed in:—*

STORM OVERFLOWS.

*North Side.*

| Level. | Size. | Outlet. | Position. |
|---|---|---|---|
| +3·0 | 6 ft. Bl. | Stamford Brook | At Hammersmith Creek. 9¾ miles above London Bridge. |
| +0·60 | 5 ft. Bl. | Brook Green Sewer. | At Bridge Road, Hammersmith. 9¼ miles above London Bridge |
| −2·90 | 9′ 6″ × 9·0 | Counters Creek | At Cremorne. 5¼ miles above London Bridge. |
| 0·00 | 4′ 0″ × 2·8 | Church Street Sewer. | At Chelsea Embankment. 4¾ miles above London Bridge. |
| 0·00 | 4′ 0″ × 2′ 8″ | Queen Street Sewer. | At Chelsea Embankment. 4¾ miles above London Bridge. |

Sir J. W. Bazalgette, C.B.

11 April 1888.

*North Side.*

| Level. | Size. | Outlet. | Position. |
|---|---|---|---|
| 0·00 | 4′ 0″ × 2·8 | Smith Street Sewer. | At Chelsea Embankment. 4½ miles above London Bridge. |
| −1·20 | 9′ 2″ × 9·6 | Ranelagh Sewer | At Chelsea Embankment. 4 miles above London Bridge. |
| −1·20 | 6′ 9″ Bl. | Western P. S. - | At Pimlico. 3¾ miles above London Bridge. |
| −3·0 | 18′ 0″ × 20·0 | King's Scholars Pond. | At Vauxhall Bridge. 3 miles above London Bridge. |
| −0·7 | 2′ 0″ | Grosvenor Ditch | At Millbank. 2½ miles above London Bridge. |
| −0·2 | 2′ 6″ × 2·0 | Horseferry Road Sewer. | At Millbank Street. 2½ miles above London Bridge. |
| −0·2 | 2′ 6″ × 2·0 | Wood Street Sewer. | At Millbank Street 2½ miles above London Bridge. |
| −8·5 | No. 2 5′ 9″ × 2·9 No. 4 2′ 6″ diam. | Regent and Victoria Street Sewers. | At Charing Cross Bridge. 1½ miles above London Bridge. |
| −10·0 | No. 4 3′ 0″ Bl. | Northumberland Street Sewer. | At Charing Cross Bridge. 1½ miles above London Bridge. |
| −10·0 | No. 2 4′ 0″ × 2·9 | Savoy Street Sewer. | At Waterloo Bridge. 1¼ miles above London Bridge. |
| −10·0 | No. 2 4′ 0″ × 2·9 | Norfolk Street Sewer. | Opposite Temple Station. 1⅛ miles above London Bridge. |
| −10·0 | No. 2 4′ 0″ × 2·9 | Essex Street Sewer. | At Temple Pier. 1 mile above London Bridge. |
| −5·0 | No. 2 9′ 9″ × 7·0 | Fleet Sewer - | At Blackfriars Bridge. ⅜ mile above London Bridge. |
| −3·7 | 2′ 0″ Pipe | Bennetts Hill Sewer. | At Paul's Wharf. ⅛ mile above London Bridge. |
| +4·8 | 8′ 0″ × 4·7 | Dowgate Dock Sewer. | At Dowgate Hill. ⅛ mile above London Bridge. |
| −3·4 | 8′ 2″ × 7·10 | London Bridge | At London Bridge. |
| −1·17 | 4′ 0″ Bl. | Beer Lane Sewer | At Wool Quay, Thames Street. ¼ mile below London Bridge. |
| 0·00 | 4′ 9″ × 3·0 | Irongate Sewer | At Irongate Stairs. ¼ mile below London Bridge. |
| −3·0 | 3′ 6″ × 3·2 | Nightingale Lane Sewer. | Between St. Katherine and London Docks. ⅜ mile below London Bridge. |
| +0·4 | 3′ 0″ × 3·0 | Hermitage Street Sewer. | At Union Wharf. 1 mile below London Bridge. |
| +2·1 | 4′ 0″ × 2·8 | Wapping Wall Sewer. | At Gravel Lane. 1½ miles below London Bridge. |
| −1·6 | 3′ 0″ Bl. | Wapping Wall Sewer. | At Frying Pan Stairs. 1⅝ miles below London Bridge. |
| −5·6 | 3′ 0″ Bl. | Pennington Street Sewer. | At Coal Stairs. 2 miles below London Bridge. |
| −4·5 | 4′ 0″ × 2·8 | Ratcliffe Highway. | At Bell Wharf. 2 miles below London Bridge. |
| −5·8 | No. 2 3′ 0″ Bl. | Ratcliffe Highway. | At Ratcliffe Cross. 2¼ miles below London Bridge. |
| +0·63 | 4′ 6″ × 3·0 | Limekiln Dock - | At Limehouse Entrance West India Docks. 2¾ miles below London Bridge. |
| −5·0 | 2′ 9″ Bl. | Great Sluice - | At Blackwall. 6 miles below London Bridge. |
| −5·5 | 2·10 Bl. | Blackwall Sewer | At Blackwall Entrance West India Docks. 6¼ miles below London Bridge. |
| +4·5 | No. 2 8′ 6″ × 6·6 | High Level and Middle Level Sewers. | At Old Ford on River Lea. 7 miles below London Bridge to River Lea. |
| +12·1 | 2′ 6″ | Eastern Counties Railway Sewer. | At Old Ford on River Lea. 7 miles below London Bridge to River Lea. |

*District Outlets.*

| | | | |
|---|---|---|---|
| −2·1 | 3′ 2″ × 2·6 | Cold Harbour Sluice. | At Blackwall. 6⅜ miles below London Bridge. |
| −7·2 | 2′ 0″ Bl. | North Woolwich | At North Woolwich. 9¾ miles below London Bridge. |

*West Ham Drainage into River Lea.*

| | | | |
|---|---|---|---|
| −6·2 | No. 2 5′ 3″ × 3·6 | Outfalls - - | At Pumping Station and Barking Road. 7 miles below London Bridge to River Lea. |

*Private Outlet.*

| | | | |
|---|---|---|---|
| 0·00 | 3 ft. Bl. | Beckton Gas Works. | At Barking Creek. 11 miles below London Bridge. |

*South Side.*

| | | | |
|---|---|---|---|
| +5·0 | 6′ 0″ × 2·6 | Putney Gutter - | At Putney Bridge. 7⅛ miles above London Bridge. |
| +4·0 | 4′ 6″ Bl. | Low Level Sewer | At Jews' Row, Wandsworth. 6⅛ miles above London Bridge. |
| +5·40 | 5′ 7″ × 5·1 | Falcon Brook - | At Battersea Creek. 5⅝ miles above London Bridge. |

*South Side.*

| Level. | Size. | Outlet. | Position. |
|---|---|---|---|
| +3·30 | 4′ 0″ × 2·8 | Low Level - | At Bridge Road, Battersea. 4⅝ miles above London Bridge. |
| −0·20 | 9′ 0 × 9·0 | Heathwall Sewer | At Nine Elms. 3¼ miles above London Bridge. |
| −1·50 | 8′ 3″ × 5·6 | Storm outlet from Clapham. | At Vauxhall Bridge. 2¼ miles above London Bridge. |
| −1·50 | 11′ 0″ × 7·6 | Storm outlet from Brixton. | At Vauxhall Bridge. 2¾ miles above London Bridge. |
| −4·8 | 4′ 0″ × 5·0 | The Arnold Sewer. | At Waterloo Bridge. 1¼ miles above London Bridge. |
| −3·4 | 5′ 6″ × 4·6 | Battle Bridge Sewer. | At Battle Bridge Stairs. ¼ mile below London Bridge. |
| −4·8 | 5′ 0″ × 4·10 | Great St. John's Sluice. | At Horselydown. ⅜ mile below London Bridge. |
| −6·4 | 6′ 6″ × 6·6 | Duffield Sewer - | At Bermondsey Wall. 1¼ miles below London Bridge. |
| −6·58 | 10 ft. Bl. | Earl Sewer - | At Rotherhithe. 3½ miles below London Bridge. |
| +4·5 | No. 2. { 10′ 6″ × 10·6 | High Level Sewer. | At Deptford Creek. 4⅝ miles below London Bridge to Deptford Creek. |

NOTE.—Some of the outlets are larger than the sewers draining to them.

12,729. And all but two are self-acting, are they not?—Yes.

12,730. Then I do not at the present time see what information this table of rainfall which you handed in would give one, beyond what was happening at these particular outfalls?—It would not.

12,731. According to you, the rain and the pressure upon the sewers may be very local in London. You said you could not compare Greenwich and Kew?—No.

12,732. Therefore one thing may be happening at one time in one part of London and a very different thing in another?—Yes; these things happen in different parts of the river at each end of London, and I think may fairly represent what is going on between them.

12,733. As you have put in this diagram, can you tell me what is a quarter of an inch of rainfall upon a square mile in cubic feet?—I cannot give it at the moment, but it would be something very considerable in cubic feet, and on the other hand the amount of absorption and evaporation upon a large surface is very great.

12,734. Now, with regard to the Savoy sewer table; that was a record, if I remember rightly, of how much rain ran off in a period of 36 hours?—Yes.

12,735. There fell 2·90 inches in the 36 hours; do you know at all how that was distributed over the 36 hours, or have you only got what appears on the table?—I have only what appears upon the table.

12,736. You have no means of telling us whether or not it was raining right up to the end of the 36 hours or not?—I believe it was raining continuously.

12,737. I need hardly say that the rain which had fallen within the last half hour or an hour, or even a longer period than that, would not have got to the sewer at all, would it? You would not expect the whole of the water to find its way into the sewerage during the 36 hours?—No, but it would get in rapidly here, because this is a sewer with a rapid falling surface.

12,738. You find in London, do you not, with paved courts and roads and comparatively very little garden ground, that a very much larger proportion of the rainfall finds its way into the sewers than if you deal with another and less urban kind of area?—Yes, undoubtedly.

12,739. Taking the populous parts of London; Park Lane upon the one side, and four or five miles eastward of that upon the other; taking the Thames at the southern boundary, and then going up the Marylebone Road, and taking right through the populous parts; what proportion of rainfall do you think finds its way into the sewers?—If you include the Parks?

12,740. I excluded the Parks on purpose. I take it east of Hyde Park and west of Victoria Park, and bounded by the Thames upon the south?—That being an urban portion, I should think it would behave very much as this area in the table did.

12,741. That not more than 74½ per cent. would find its way to the sewers?—No.

12,742. I mean, taking all the rain, not merely the portion that went off while the rain was falling?—The area drained to the Ratcliffe Highway and the Savoy Street sewers is quite as dense as that; it fairly represents the town area.

12,743. But that was 2·88 inches in the 25 hours, and 300 acres were drained?—Yes.

12,744. But you do not suggest that it all gets off in the 25 hours?—The sewage will not begin running so quickly as the rain begins to fall; it will begin a little later, and continue a little later: you will get it cut off at one end and put on at the other.

12,745. But you will observe, "Total quantities of "rain discharged by the sewer in the above men-"tioned time;" it disregards all that which went off afterwards. Now have you any doubt that a considerable portion of that rain went off afterwards?—Some of it would go off afterwards.

12,746. You stated that the three outfall sewers upon the north side are capable of sending out 33,000 cubic feet per minute?—Yes.

12,747. Would you divide that, if you please, or is it equally divided into high level, low level, and middle level?—In that sewer there are three sewers running parallel with each other, and communicating with each other so that they can relieve each other. They communicate by arches.

12,748. Those are the three pipes which take you from Abbey Mills to Barking?—Yes.

12,749. They are not, as a matter of fact, fed by drains upon the way?—No.

12,750. Then what is there at Abbey Mills which delivers to Abbey Mills?—There are two sewers and the low level sewer.

12,751. All three go to Abbey Mills?—Yes, the low level being 10 feet 3 inches in diameter.

12,752. And how much do they deliver at Abbey Mills?—10,300 cubic feet a minute.

12,753. And the other two?—I think each of them is capable of delivering 11,000 cubic feet a minute.

12,754. If you would rather give me the actual figures, I will postpone the question. Now do they drain equal areas?—No.

*Sir J. W. Bazalgette, C.B.*

11 April 1883.

12,755. It would be convenient, I think, if you could put upon a small map, if possible, the area which is drained upon the north side by the high level, low level, and the middle level sewers?—I have given you that.

12,756. You read some acreages off, but I should be glad to see it upon a map (*exhibiting a map to the witness*). The green colour is the low level?—It is.

12,757. And the blue the middle, and the yellow the hgh level?—It is.

12,758. Am I right in saying that the low level delivers to Abbey Mills with 10 feet 3 inches diameter?—That is right.

12,759. The middle level appears to join the high level at some intermediate point. Is that so, or does it only run parallel?—They run parallel to the river Lea. They join at the river Lea.

12,760. Then I may take it that there is one sewer from that point to the Abbey Mills. Will you tell me what is the diameter of the sewer from the point of unction by the river Lea down to Abbey Mills?—Two nine feet sewers.

12,761. Then the high level, is that a nine feet sewer?—That is 12 feet.

12,762. And the middle level, how much is that?—That is 10 feet 6.

12,763. Does the upper part of the green go into the low level, or is that only accidentally coloured the same colour?—It goes into the low level.

12,764. Will you tell us the proportion of the green as distinguished from the yellow and the blue areas?—I think I can perhaps save you some trouble if I explain to you that the high level sewer is much larger compared to its area and population than the low level. Mr. Baldwin Latham fell into the mistake; he said the population upon the high level sewer is so large that in time of storm it will not be able to take the sewage off.

12,765. What I really want is this, I want the population of the green, the blue, and the yellow approximately?—It will be impossible to get that, except very approximately.

(*Mr. Norman Bazalgette.*) I may state that the next witness who will follow Sir Joseph is prepared to give those figures.

(*Mr. Webster.*) I also want the storm outlet shown with regard to the numbers in those districts.

Adjourned to Tuesday, 1st May, at half past 12 o'clock.

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# THIRTY-THIRD DAY.

## Tuesday, 22nd May 1883.

PRESENT:

The Right Hon. LORD BRAMWELL, F.R.S., in the Chair.

Sir John Coode, Mem. Inst., C.E.
Colonel C. B. Ewart, C.B., R.E.
Professor Williamson, F.R.S.
François de Chaumont, Esq., M.D., F.R.S.
Thomas Stevenson, Esq., M.D.
James Abernethy, Esq., F.R.S.E., Mem. Inst., C.E.

Wm. Pole, Esq., F.R.S., *Secretary*.

Sir Joseph Bazalgette recalled; further cross-examined by Mr. Webster.

12,766. You were good enough to say upon the last occasion that you would produce some reports in which the effect of the oxidation of the sewage as a deodorising factor was taken into consideration as an element of the scheme?—I did.

12,767. I do not know if it is much to read,—if it is I would ask you to read it afterwards?—Yes, there is a good deal about it in various parts.

*Sir J. W. Bazalgette.*

22 May 1883.

12,768. Then I will ask you to read it afterwards, but I will ask you this question upon it; is it reduced into figures at all as a result?—It is.

12,769. Perhaps you can read the passage in which

*Sir J. W. Bazalgette.*

22 May 1883.

it is so reduced to a result?—It would be difficult to do that, as it is spread over a good deal of the paper.

12,770. I should wish it to be upon the notes, but I will ask you to read it now unless there is one passage in which the result is given in figures, or if you will state the effect or the practical result if arrived at?—The report is the Report of Messrs. Bidder, Hawksley, and Bazalgette, and the date is the 6th of April 1858, and the passages to which I will call attention by-and-bye are contained upon pages 66, 67, 68, 70, 71, and 88 of that Report, and pages 116 and 118 of the Report of Dr. Letheby.

12,771. Of what date?—It is an appendix to the same report.

12,772. Could you now give us without now reading the passages what the effect of it was stated to be, either with respect to the quantities of sewage or time or anything of the kind?—The effect of it is generally that the process of oxidation is taking place in the river, and I think I can give you one result very shortly in Conclusion No. 4 of Dr. Letheby's Report; he says: "This may be obviated by defecting the sewage by "means of lime, and allowing the clear liquor only to "be discharged into the Thames, or by discharging "the sewage into the Thames in such a manner that "it will mix with and be diluted by 200 or 300 times "its bulk of water."

12,773. I think that is the report of the 15th March 1858?—It is.

12,774. The conclusion that you have read from Dr. Letheby's Report commences:—"The mischief "which really results" (I am reading from paragraph 3 of the report) "from the present mode of "disposing the sewage is caused by the insoluble "organic matters which collect upon the banks of the "river near to the sewers, and there undergo per-"petual putrefaction. That this may be obviated by "defecting the sewage by means of lime." That of course has not been done?—No.

12,775. "And allowing the clear liquor only to be "discharged into the Thames, or by discharging the "sewage into the Thames in such a manner that it "will mix with and be diluted by 200 or 300 times "its bulk of water." That means of course that each bulk of sewage will have 200 or 300 times of unpolluted river or sea to mix with?—Yes.

12,776. Have you in any other conclusion as regards the effect of oxidation drawn attention to anything other than that which is stated to be a mixing with water?—Yes. Then I am afraid I must read.

12,777. But have you any other conclusions in figures or time?—I am afraid I cannot give it you shortly.

12,778. Then you shall give it afterwards; now I will draw your attention to a table you put in upon the last occasion, it is to follow Question No. 12,502. Your total area is 50·21 square miles upon the northern side of the Thames, is it not?—That is correct.

12,779. Have you taken that as extracted from the original report which you made?—Yes, except that my Report of 1856 gives the total area as 51·44 square miles.

12,780. Now I will attention to this; it is not a very large difference, but for the purpose of accurate comparison I may want it afterwards. I am told that the summary of the mileage upon the north side in that report is 51·6 square miles.

(*Sir John Coode.*) Does it matter whether it is 51·4 or whether it is 51·6?

12,781. (*Mr. Webster.*) It is not that; I am comparing it with the 50·21; it is a difference of a square mile and a half; it is not very important, but I want to ask Sir Joseph Bazalgette whether he can tell us where the difference occurs (*to the witness*) because you have put in a table showing 50·21?—I cannot say where the difference arises.

12,782. Would you kindly just look through the detail and let us know what the accurate figure is, not for the purpose of showing that anything is wrong but for the purpose of making a comparison with the figures themselves. Now of the 50·21 or of the 51·6 what is the area of the western district. I am told from your own figures that it is 14½ square miles?—That is about it.

12,783. I am told that your 50·21 does not include Acton?—It does not include Acton.

12,784. Will you tell me what is the area of Acton. I am told it is four and a half square miles?—Yes, that is so.

12,785. Then for my purpose these two figures of 14½ square miles of the western district, and the 4½ of Acton are not included?—No.

12,786. You stated upon the last occasion that one of the sewers upon the north side was made 10 feet 3, because you thought that some time or other you might include the western district, are you sure that that was the reason?—Yes.

12,787. That 10 feet three sewer only goes to Abbey Mills, does it; below Abbey Mills there are three 9 feet sewers, are there not?—Yes.

12,788. Then, as a matter of fact, the three sewers from Abbey Mills to the outfall are three 9 feet sewers, while the three sewers down to Abbey Mills are two nines and a 10 foot three?—Yes, that is correct.

12,789. The gradient or the fall is the same, is it not?—Yes.

12,790. What is the difference in cubic feet per minute between what the three nines will take away, as compared with the two nines, and the 10 feet three?—They each discharge 11,000 cubic feet per minute.

12,791. Each of the nine's?—Yes.

12,792. What excess quantity can be brought down to Abbey Mills by the 10 feet three sewer?—The 10 feet three sewer will bring down 14,000 cubic feet per minute, 3,000 more; but the 9 feet sewers above Abbey Mills have a discharging capacity of 3,690 cubic feet per minute in excess of the quantity they were intended to carry; and the flow of all the three 9 feet sewers is limited below Abbey Mills, and they thus become of the right discharging capacity for the duties they were intended to perform.

12,793. These capacities of the 11,000 and the 14,000 are, are they not, assuming the sewers to run full?—Yes, they are.

12,794. Are not the storm outlets placed at a level below that which will admit of the sewers running full?—No, above; at least the weirs are placed so that when the sewers run full they overflow.

12,795. I want to know one way or the other, do I understand you to say that no storm outlet can act until the sewer is running full; is it not the fact that the weir is below the crown of the sewer?—It is.

12,796. How much below, 12 inches?—Generally something like 12 inches.

12,797. Then, as a matter of fact the storm outlets do act when the water or the sewage has risen to within 12 inches of the top?—They begin to act, but they do not prevent its rising to the top and so running full.

12,798. That depends upon the hydrostatic pressure or the water coming down, but what I want to know is, what quantity would be passing out at the storm outlets, assuming the sewer to be running full; can you give us that information in any shape?—No, I cannot.

12,799. By "storm outlets" you mean the outlets which go into the river?—Yes.

12,800. I want to know what quantity would be running out of the storm outlets if your sewer is running full, that is to say, supposing this (*illustrating by a folded sheet of paper*) to be the barrel of the sewer, the storm outlets are a foot below the top, so that the storm outlets would be acting as soon as the sewage rises to within one foot of the top, now the capacity or what the sewer will take away, that is to say, the 14,000 cubic feet a minute, is upon the basis that the sewers are running full, is it not?—Will you permit me to make a correction there? A sewer (though it may seem strange to say it) discharges more when it

is not running quite full than when it is running full.

12,801. Do you mean it is better that there should be an air space at the top?—I mean to say the frictional surface is greater when it is running full than when there is a small space left.

12,802. What would be the discharge when it is running full?—11,000 cubic feet when it is nearly full.

12,803. What would be the discharge capacity when it is running within a foot of the top?—About the same quantity, and if it rose a little higher to within about 9 inches, it would discharge more than if it were running quite full. Mr. Baldwin Latham, I think, adops a formula for discharging his sewer which gives a higher result than I have adopted for mine, but I have taken the same formula for the outfall sewer, and for the discharge of these sewers, and if you take my formula for the discharge of the outfall sewer, you must do the same with the rest, if you add on to one you must add on to the other.

12,804. You called attention upon the last occasion to the large quantity per head going out upon the south side as compared to the north side, I think you spoke of 50 gallons a head?—Forty-six gallons, I think, 46·88 or nearly 47 gallons.

12,805. In the first place in getting at your 47 gallons per head, you assumed, did you not, that the whole of the southern area drained into the Southern outfall?—No, I assumed that the whole of that population residing upon the southern side drained into it.

12,806. That is nearly the same thing, is it not?—Not quite.

(*Chairman.*) I have an impression that Sir Joseph told us that there was a portion of the southern area that was not drained at all.

12,807. (*Mr. Webster.*) I am coming to that directly, my Lord. (*To the witness.*) As a matter of fact there is a considerable strip, is there not, of the southern area between the Southern outfall sewer and the river itself, and also another part of the southern area which is not drained into the river?—There is.

12,808. Would you give us at all approximately with reference either to population or to area, or to anything that would be some guide to us, what part of the 51 square miles or of the population represented thereby, does not drain into the river. I will give you your population if you require it?—According to my calculation there are on the south side altogether, including that which is outside the area, 51·78 square miles drained into the river.

12,809. 51·75 you put it in your table, but never mind that?—Now there are upon the south side altogether 67·78 square miles. Now, I make out that in the marsh lands, the portion of the area draining towards Beckenham away from the metropolis, and Bostal Heath, and commons of that kind there are 6¼ square miles. And there are undrained, the surface waters of which fall into the rivers Quaggy, Ravensbourne, Wandle, and Graveney, and the Beverley Brook about 10 square miles more.

12,810. (*Sir John Coode.*) When you say "undrained" do you mean not sewered?—Not provided with any sewers.

12,811. I think that sum of 16·57 square miles is upon your table?—Yes.

12,812. (*Mr. Webster.*) When you arrived at your 47 gallons a head upon the south side, which you arrived at by calling attention to the tanneries and other things of that kind, which had water in them, what population did you take, did you take the whole of the population upon the 51 square miles?—Yes.

12,813. Is there not in that 51 square miles a very considerable strip of the south side of the river, which drains direct into the river, for instance between Nine Elms and Bermondsey?—No, none at all.

12,814. Then you say it is correct to take the whole of the population of that 51 square miles?—Yes.

12,815. Then I must ask you what population you took when you brought in your 46·88 gallons; in your answer to Question 12,524 you did not say what population you took; did you not then take the entire southern population?—For the 51 square miles I took it as 1,113,000.

12,816. I must go back again to what you said just now; you said that all the drainage along the banks had been diverted to the sewers, but do not you remember telling the Commission the very first day they met that you were advised some three years ago that you, or the district boards, ought to connect all those places with the sewers. Will you just turn to Question 39 with regard to the area undrained or unconnected upon the southern side; you pointed out that there were outfalls draining into the Thames which you had given notice to local boards to divert. Did you mean that what is left now is not worth considering when you said that there is no area which still drains into the Thames between the outfall sewer and the river?—I take that practically is the case, there may be some houses which do.

12,817. Now one question, if you please, upon this; you have accounted for the high quantity of gallons per head discharged upon the south side by referring to the Bermondsey inlets, the tanneries and other such matters; have you got the hourly discharge of that day, the 12th July, 1876, upon which Mr. Baldwin Latham's deductions and your own conclusions were given?—Yes.

12,818. Would you just put it in?—I think that has already been put in.

12,819. I think not; it was upon the Mud Inquiry.

(*Chairman.*) I think this evidence ought to have been given in a different way; it is not as though you were getting facts from a reluctant witness; the facts are agreed upon, and why could not they have been put in a different form which we could all understand.

(*Mr. Webster.*) We suggest that it is leakage into the sewer to a very considerable extent upon the southern side. Sir Joseph Bazalgette comes and says (and we respect his opinion), that he thinks it is due to the tidal water getting in through certain inlets. I can get information which apparently would indicate that it is impossible to account for it in that way, and I need not remind your lordship that it is my duty to put that to Sir Joseph Bazalgette.

(*Chairman.*) Certainly. Do not imagine I am suggesting that you are pursuing a useless inquiry; may I ask what is your object at the present moment.

(*Mr. Webster.*) The first thing is this; the very first sending in of leakage water would have no bad effect, because it would dilute the particular sewage that was going in at the bottom, but it may have, and we believe does have, the effect of choking the sewer with that water low down, so that it is full of water, that it was not intended to carry off, and the result is that the sewage in the upper districts does go into the Thames in a way that is was never intended to go.

(*Chairman.*) Through the storm overflows?

12,820. (*Mr. Webster.*) Through the storm overflows (*To the witness*). Can you tell me at what time of the tide the water is taken in by the Bermondsey inlets?—Do you mean for flushing?

12,821. Not for flushing only, but for the use of these tanneries that you mentioned?—I apprehend that all water taken from the river would be from half tide to high water, and down to half tide again.

12,822. I do not wish for an "apprehension" but do you know as a fact at what time of the tide that water is taken in?—I presume at high water more particularly.

12,823. Could you tell me what would be the total quantity taken in?—I stated it in my evidence in chief.

12,824. That is to say, 4,000,000 gallons in 24 hours?—Yes.

12,825. Does that assume a continuous flow?—No, that assumes that was taken in at the two high waters in the 24 hours.

*Sir J. W. Bazalgette.*

22 May 1883.

12,826. You say 4,000,000 gallons in the two periods of high tide?—Yes, two periods of six hours.

12,827. Can you tell me what times the high tides were upon that day. I will give them to you, 5.18 a.m. and 5.36 p.m. I will ask you to look at this table of the flow, do you suggest that there is any period of the flow in which you could indicate that there was excess water, due to water taken in at the inlets at high tide; will you kindly look at it, from midnight to noon. (*The following Table was handed to the witness.*)

CROSSNESS SEWAGE DISCHARGE.

Hourly Sewage Discharge in dry weather, 12th July 1876. No rainfall from the 24th June to 6th July, on that day, at 8 o'clock, p.m., when 0·16 in. fell, 0·01 in. on the 7th, and 0·02 in. on the 8th.

| Time. | Gallons. | Per cent. | Remarks. |
|---|---|---|---|
| Midnight | | | |
| 0.00 a.m. | | | |
| 1.00 | 1,971,524 | 3·0 | Sewage in main sewer kept at the level of −8·00 throughout the whole time of experiment. |
| 2.00 | 2,198,357 | 4·3 | |
| 3.00 | 1,887,064 | 3·6 | |
| 4.00 | 1,940,153 | 3·8 | |
| 5.00 | 1,351,350 | 2·6 | |
| 6.00 | 1,339,285 min. | 2·6 | Minimum. |
| 7.00 | 1,365,828 | 2·6 | |
| 8.00 | 1,467,180 | 2·8 | |
| 9.00 | 1,587,836 | 3·1 | |
| 10.00 | 2,109,072 | 4·1 | Average. |
| 11.00 | 2,116,311 | 4·1 | |
| 12.00 | 2,825,769 | 5·4 | |
| P.M. | | | |
| 1.00 | 2,340,731 | 4·5 | |
| 2.00 | 2,784,746 | 5·4 | |
| 3.00 | 2,502,410 | 4·8 | |
| 4.00 | 2,350,384 | 4·5 | Maximum produced probably from 8 to 12. |
| 5.00 | 2,524,129 | 4·8 | |
| 6.00 | 3,091,213 max. | 6·0 | |
| 7.00 | 2,999,514 | 5·8 | |
| 8.00 | 2,758,202 | 5·3 | |
| 9.00 | 2,277,990 | 4·4 | |
| 10.00 | 2,234,554 | 4·3 | Maximum, 3,091,213, is 42 per cent. in excess of mean. |
| 11.00 | 2,101,832 | 4·1 | Minimum, 1,339,285, is 38 per cent. less than mean. |
| 12.00 | 2,130,789 | 4·1 | The maximum is 2·3 times the minimum. |
| | 52,256,223 | 100·0 | |
| Mean | 2,177,343 | — | Average 4·25. |

(*Mr. Webster to the Chairman.*) This is the particular day, my lord, upon which they gauged; from which the calculation is taken, when you will see 1,971,000 at one o'clock, and 2,198,000 at two o'clock.

(*Chairman.*) What is that?

12,828. (*Mr. Webster.*) Gallons flowing out at Crossness outfall, there having been no rain for the previous 12 days; 3 o'clock 1,877,000 gallons, 4 o'clock 1,940,000 gallons, 5 o'clock, 1,351,000 gallons, 6 o'clock 1,339,000 gallons, and so on (*to the witness*). I suggest to you that there is no fluctuation of any kind, such as would appear if it were due to an abnormal taking in of water at high tide? I do not think I can go with you there.

12,829. Will you tell us at what hour in the first 12 hours, or if you please the first 16 hours that water went in?—It begins with a high flow at about midday.

12,830. What do you mean by the "high-flow" there?—The flow has risen to four or five per cent., 2,800,000, and it continues a high flow until 8 o'clock that evening.

12,831. I should like to know this, and I point it out to you; if I am correct (the dead low water you know, is just before noon); how is that table consistent with the view that the large quantity is due to any tidal influx of water through those inlet pipes twice a day?—I think if you take the distance of these inlets from the outlets, and calculate the time it would take flowing down to the outlets, you will find it has arrived at the outlets somewhere about that period, which shows the high flow.

12,832. I should like you, if you please, if you say that that is what this table shows, kindly to put your inference or your reasoning in the shape of an answer which can appear on the notes?—It wants a little working out, but it does appear to me, looking at the distance of the inlets from the outlets, and the rate of the flow that that is consistent with my theory.

12,833. Do you know whether that was a neap or a flood tide?—I do not know.

12,834. I will tell you that it was a neap tide, but do you know what time, or how long the water could come in upon that day at all?—I did not go into the calculation.

12,835. Will you oblige me by going into it. I suggest to you that this table indicates and proves that your theory of the excess being accounted for by the inlets at Bermondsey and elsewhere cannot be correct; therefore I will ask you kindly to consider it in order that I may not take you by surprise?—I will do so. I think you will find it is consistent with my theory.

12,836. You will remember the time of the tide, and the time of the flow?—Yes.

(*Chairman.*) You suggest that this great discharge is attributable to leakage, while Sir Joseph Bazalgette on the other hand suggests that it is attributable to the inlets of the tanneries.

(*Witness.*) I know as a matter of fact that about one-fourth of the leakage is let in by the tanneries.

13,837. (*Mr. Webster.*) Upon the last occasion you said you could not tell us how much; you said you thought it would be about that?—I put in the report with respect to it.

12,838. But as to the quantity, you said you could not give us the quantity?—I said, I think, that three-fourths of the excess arose from flushing and so on, and one-fourth from the tanneries and factories.

(*Chairman.*) But what I would ask is this. Let it get in from whatever cause it may, would it not equally cause a filling of the sewers.

(*Mr. Webster.*) Certainly, but you know the way in which it was put was, that it was a burden upon the back of the Metropolitan Board of Works, which they could not help, whereas, if it were the sewage that leaked, it was a defect which ought to be remedied quite independent of the rights of any riparian owners or manufacturers.

(*Witness.*) That is not the way in which I put it—the way I put it was, that we flush the sewers only in dry weather when there is a very small flow, and we do not flush the sewers in times when there is heavy rain and when the sewers are likely to be overcharged, and therefore that quantity does not take up the capacity of the sewer at the time when the capacity of the sewer is most likely to be wanted.

12,839. (*Mr. Webster to the witness.*) Now you proposed to tell us, upon the last occasion, upon what area the sewers were calculated to take off a quarter-of-an-inch of rainfall in the 24 hours upon the northern side—in fact upon both sides, and upon what area an eighth of an inch in 24 hours?—That is the calculation that was made in 1856. The calculation then made was to take off a quarter-of-an-inch of rain upon the north side from 28·7 square miles, and an eighth of an inch from 22·8 square miles, or a total of 51·5 square miles. Upon the south side, to take a quarter of an inch from 14·3

square miles, and an eighth of an inch from 28·3 square miles or a total of 42·6 square miles.

12,840. You have given already to-day a capacity of discharge upon the north side of 33,000 cubic feet per minute. That report you referred to contemplated, I think, 20,000 cubic feet per minute as being the capacity of the outfall sewer?—That report left it open.

12,841. But you dealt with it as that, did you not?—Yes, I think at that time we contemplated dealing with the western sewage separately.

12,842. Also did it not contemplate taking in the 4½ miles of Acton?—No, nor do I contemplate taking in the 4½ miles of Acton now.

12,843. Are the 4½ square miles included in your 50, or not?—No.

12,844. Then you have to take away from the 50 square miles only the 14½ square miles of the western district?—Quite so.

12,845. Then the area, less the western district, would, roughly speaking, be 36¾ square miles?—Yes.

12,846. And for that did you, or did you not think at that time that a discharge capacity of 20,000 cubic feet a minute was sufficient?—28,000 was what I thought sufficient.

12,847. Including the western district, or not?—Excluding the western district.

12,848. I think you must be making a mistake there, because I can scarcely understand how 33,000 is to be sufficient if you include the western district?—Because the western district gives about 5,000 cubic feet a minute, I think.

12,849. Do I understand you to say that?—Yes, that is right.

12,850. Do you justify the 33,000 as being sufficient for the present time upon the theory that the western only produces 5,000?—Yes, I do, undoubtedly.

12,851. Do you say that the 33,000 cubic feet per minute has allowed any provision for increase of population upon the old area that was taken in?—Yes.

12,852. How much. You told us on the last occasion that the increase was partly compensated by a more regular or a more extended flow—what part of the 33,000 do you say provides for the increase in the population?—The report of 1856 provided for an increase of population.

12,853. But you do not follow me. You said you thought 28,000 cubic feet per minute discharged from the outfall sewer———

(*Chairman.*) Do you mean a sewer which had a capacity for discharging so much?

(*Mr. Webster.*) Yes, my Lord. (*to the witness.*) Now I ask you—it does not matter how you give the information—what part of that 28,000 cubic feet per minute represented the outfall capacity or power, for increase of population. What margin was there?

(*Chairman.*) As I understand the question is this; how much did you suppose would be discharged from the existing population served by the sewer.

12,854. (*Mr. Webster.*) How much did you suppose would be actually discharged in sewage and rainfall, the population being as it then was?—I did not make that calculation.

12,855. But you have said to us that 28,000 cubic feet per minute was what you thought necessary without the western district.

(*Chairman.*) What he thought would be desirable.

12,856. (*Mr. Webster to the witness.*) Did that take into account the increase of population in that district, or did it not?—It did take into account the increase of the population.

12,857. How much of the 28,000 cubic feet a minute was the discharge capacity which was to meet the increase of population; what did you assume the normal flow would be for the next 12 months?—The population at that time was about 1,600,000, exclusive of the western division, or 1,766,000 with the western division. The population contemplated was 2,056,800 or, with the western division, 2,353,900. Of course I did not go into the calculation how much will it take to carry it now, and how much in the future, but I looked to what it would have to carry in the future and made my provision for that.

12,858. Do I understand you to say that the 28,000 cubic feet a minute were considered desirable for a population of 2,353,900?—Yes, with certain other assumptions which I have given before.

12,859. Then you did not estimate it for the existing population and then add on a margin, but you took it at what would be necessary in the future with the existing population?—Yes, I can give it you in detail.

12,860. (*Chairman.*) It is so clear to my mind that Sir Joseph Bazalgette ought to be able to give an intelligible answer to the question you intended to put, that I cannot understand what the difficulty is. (*To the witness.*) I suppose you reckoned that there would be a certain discharge per head?—Yes.

12,861. What were the number of heads at the time that you made your sewer that were to be served?

(*Mr. Webster.*) Upon the northern side.

(*Witness.*) 1,766,000, including the western division; excluding the western division it is 1,614,000.

12,862. (*Chairman.*) You calculated that they would discharge a certain quantity of sewage?—I did not do that, that was not my object; was to see how large the sewer should be to provide for future generations, and I knew if it would take the larger it would take the lesser, so I did not think it necessary to calculate the lesser.

(*Mr. Webster.*) Your answer is that you considered 28,000 cubic feet a minute was sufficient for 2,353,900.

12,863. (*Chairman.*) You say I will not trouble myself to calculate what is wanted at the present moment, but you said, I will make my sewer big enough for the remainder of the century?—Yes; I thought if the hole was big enough for the cat the kitten could get through.

(*Mr. Webster.*) If you were correct in saying that 28,000 cubic feet a minute was excluding the western district, I had better model all my questions with regard to that excluded district, and will then ask you what population did you take, excluding the western district.

(*Chairman.*) I would rather you asked the witness what population did he suppose would be the maximum population that those sewers would serve.

12,864. (*Sir John Coode.*) If Sir Joseph could give a direct answer to Mr. Webster's question, "How much of that 28,000 cubic feet a minute was "margin for increased population"; we should know all that we require. (*To the witness.*) You say, as I understand, that that 28,000 cubic feet a minute did include a margin; we should like to know how much margin it included?—I cannot give you that without working it out.

(*Sir John Coode.*) I think it would be better to have that than a series of round-about answers, but you can probably tell us to-morrow, of the 28,000 cubic feet, how much was margin for increased population.

(*Witness.*) It is a little complicated to do it in that way, because the rain will be much more constant than the flow of sewage; the population will increase but the area will not.

(*Sir John Coode.*) You can give us the answer to-morrow.

12,865. (*Mr. Webster.*) Just tell me with regard to this what rainfall capacity you did assume in that 28,000 cubic feet a minute, how much rain was it to provide for as well as sewage,—was it the whole of the quarter of an inch and the eighth of an inch?—An eighth of an inch upon eleven square miles, and a quarter of an inch upon twenty-seven square miles.

12,866. But can you tell me what part of your 28,000 cubic feet a minute the rainfall would take up.

(*Chairman.*) I will ask you how long was this eighth of an inch to be falling.

*Sir J. W. Bazalgette.*

22 May 1883.

(*Mr. Webster.*) In twenty-four hours,—the discharge in twenty-four hours of that quantity,—it was the discharge of an eighth of an inch of rainfall falling in that time.

(*Chairman.*) Supposing in twenty-four hours there is an eighth of an inch of rain falling.

12,867. (*Mr. Webster.*) Which has to be got rid of. (*To the witness.*) Now how much of your 28,000 cubic feet would that rainfall occupy?—That rainfall would occupy about half.

12,868. Did you assume that the eighth of an inch would be spread over the twenty-four hours equally, or that was the amount that was to be got rid of, falling during the twenty-four hours at some time or other?—It is that quantity falling at some period in the day and to be got rid of.

12,869. Did you assume it would fall in any given time?—No, I did not.

12,870. (*Chairman.*) I suppose it might all fall in half an hour?—Yes, it might, but I should qualify that by saying, not over the whole area,—if it were to fall in half an hour it would be a thunder shower.

12,871. (*Mr. Bidder.*) Does the eighth of an inch mean a discharge through the sewer equal to an eighth of an inch of rainfall over the area, or does it mean the discharge which might be expected to be produced through the sewers if the eighth of an inch fell over the area?—That is clearly what I do mean, and that represents a great variety of rainfalls under a great variety of circumstances upon areas of different kinds.

12,872. It is the latter that you mean?—It is a provision for an eighth of an inch running off in the sewers divided over the twenty-four hours.

12,873. (*Mr. Webster.*) An eighth of an inch over the whole area?—Yes, an eighth of an inch over the whole area.

12,874. (*Chairman.*) And spread over the whole time?—Yes, spread over the whole time.

12,875. (*Mr. Webster.*) Is it the fact, that the intercepting sewers, as you stated at Question No. 11, were to take the calculated quantity of sewage matter and the quarter of an inch of rain over the whole area?—I was surprised to find I got so much as an eighth of an inch.

12,876. What was the original calculation?—That which I have just given. I stated that at first I provided for a quarter of an inch.

12,877. Now a quarter of an inch in twenty-four hours if spread over the whole time would be roughly $\frac{1}{100}$th of an inch in an hour, and the eighth of an inch would be $\frac{1}{200}$th of an inch in an hour?—Yes.

12,878. Now do you put it that the rain ever does fall as slowly as the $\frac{1}{200}$th of an inch in an hour?—Yes.

12,879. Do you say that from experiment?—Yes, I have put in tables which show that.

12,880. Do you say the tables are already in?—They are, and very elaborate tables.

12,881. You have no other experiments?—You have a good many tables showing that already. I have no others than those I have put in.

12,882. Do you mean put in before this Commission?—Yes.

12,883. Would you kindly show us which the tables are in re-examination?—They are tables at Greenwich and Kew. We have taken out the various rainfalls and their duration.

12,884. I am not saying that by dividing a certain quantity of rain by a certain number of hours, you will not get a certain quantity of rain per hour, but I was asking you whether you suggested that the rain actually falls as slowly as that?—Yes, the tables show that.

12,885. You said you were dealing with 51 square miles of the northern area, and that it must not be assumed that it was always raining over the whole of that area, but I will ask you, have you any record or data as to what portions of the area it does, as a rule, rain over, out of the 51 square miles. I am told that it is exceptional if it does not rain over the whole area, but rains in part only; now have you any data to the contrary?—Yes, the data which are before the Commission. If you take the tables of rainfall at Kew and at Greenwich, it is most remarkable how varied the rainfall is. I have looked at it, and it struck me, when there is a heavy rainfall at Greenwich you will frequently find little or no rainfall at Kew, and *vice versâ*, and in very rare cases do they accord.

12,886. It is a fact is it not, that the rain in the large majority of instances, travels from the west to the east?—Yes, I expect it does.

12,887. If it be a partial rain, or a rain travelling over the area, you will have the rain falling upon the western portion before it falls upon the eastern portion?—Yes, or you may have the clouds discharge themselves in the western portion and not in the eastern,—it may clear up before they have reached the east,—they may have emptied themselves.

12,888. Now I will ask you whether or not, you think there would be any effect due to the way in which the rain passes from west to east as distinguished from the other direction,—would it not have a tendency to put a greater strain upon the sewers in the one case than the other, due to the outfall portion being congested by the rain which had previously fallen upon the western portion?—I do not think that.

12,889. At Question 12,519 you corrected Mr. Baldwin Latham's answer by saying that he had drawn a wrong deduction, because the western district sewage had not been taken off at Barking in the years 1875 and 1876; you are accurate about that?—Yes.

12,890. Is not it the fact that the western pumping station was opened in August 1875?—Yes.

12,891. Was not it taking in the western sewage after August 1875, and all through 1876?—No, the low level western sewers were not completed until April 1876, although the pumping station was completed in 1875.

12,892. I find by the Report of the Metropolitan Board of Works of the 31st December 1875, "The "western part of the low-level sewer and the pumping "station were completed and publicly opened by the "Chairman of the Board on the 5th of August last. "At this station the sewage from the low lying "western portions of the metropolis is lifted a height "of 18 feet into the low level sewer, which runs from "this point to the pumping station at Abbey Mills, "West Ham"?—Then you are incorrectly informed, or I am.

12,893. No portion of the western sewage was running then?—Yes, some portion of it.

12,894. But you suggested in your answer that the western sewage had not been diverted to Barking in the years 1875 and 1876?—I say a very small portion of the western district sewage was.

12,895. And "This year has witnessed the com- "pletion of the western portion of the Northern Low "Level Sewer, and of the pumping station in Gros- "venor Road, Pimlico, which were the only parts of "the system of main drainage unfinished at the "beginning of the year, with the exception of certain "works incidental to the main system for intercepting "the sewage from small areas in the City of London, "Wapping, and North Woolwich." What quantity do you say was coming in in 1876?—I can only give you the quantity shown by the discharge at Barking.

12,896. But you say only a small portion was coming in in 1875 and 1876; what portion?—I cannot tell you that off-hand.

12,897. I should like to know, because you criticised Mr. Latham's deduction which says, that it was going in, while you say that none of it had been diverted at that time; cannot you tell me how much of it was going in at that time?—I cannot offhand, but I will endeavour to find it.

12,898. You were going to give us a table of the dates when the storm overflows acted; have you got that?—You mean at the outfalls?

12,899. Wherever they are.—I put in a table of storm overflows as regards the sewers.

12,900. But you were to give us the dates when the waters ran out at the storm overflows?—I have given you that.

12,901. I do not think you have; you gave us the number at the time?—I told you I could not give you particulars with regard to the storm overflows, excepting at Deptford Creek.

Re-examined by Mr. Norman Bazalgette.

12,902. I will ask you first of all this,—at Question 12,631, you were asked, "What did you assume, then, "was the period during which or over which this "oscillating action might take place, as distinguished "from the space in which it would take place"; have you got a report which you made, dated 3rd April 1856?—Yes, I describe that action at pages 8, 9, and 10 of my Report of the 3rd April 1856.

12,903. What did you in that Report assume the period was in which the oscillating action would take place?—I then reported, "With regard to the point "of discharge, I cannot do better than quote from "the Report of Mr. Stephenson and Sir William "Cubitt, dated the 11th December 1854, wherein "they give the following brief summary of a series "of experiments made by the late Mr. Frank Foster "upon this subject, 'On the 15th July 1851, a float "'was put into the centre of the river opposite "'Barking Creek two hours after high water. This "'time was chosen because it was found that sewage "'discharged into the river two hours before high "'water arrived at about the same point above "'Barking Creek that sewage discharged two hours "'after high-water did by the next flood tide. At "'low water it reached 11¾ miles below that point, "'and returned with the next flood tide to one mile "'above it, having gone 12¾ miles that flood, it being "'then the period of spring tides. As the neaps "'came on, the float continued to work lower down "'each succeeding high water, and by the 24th "'July it was 13 miles below Barking Creek at high "'water, having gone down the river 14 miles dur-"'ing the falling off of spring tides to neap tides. "'As the flood again became stronger it worked up "'the river each succeeding tide until the 29th of "'July, when it again came within five miles below "'Barking Creek at high water, having worked up "'the river nine miles from high water neap tides "'to high water spring tides; the excess of the ebbs "'over the floods being only five miles in 14 days. "'Another experiment was tried at the same place "'on 6th of August 1851, it being then lowest neaps "'and the float being put down two hours after high "'water. It worked up each succeeding high water "'till top springs on the 12th of August, when it "'reached 6¼ miles above Barking Creek at high "'water. The float then again worked down the "'river till the 20th August being neaps, when at "'high water it reached 9½ miles below Barking "'Creek, being a distance of 16 miles during the "'falling off of spring tides to neap tides. The "'excess of ebbs over the floods would, in this case, "'have been about 7 miles in 14 days. The wind "'and other causes would vary the result, but it "'may be roughly assumed that a substance in "'suspension works up the river about one mile a "'day each high water as the springs strengthen, "'and down the river two miles a day as they fall "'off. The main object was, of course, to determine "'how near to London the sewage could be dis-"'charged into the river at or near high water "'without finding its way back again to the in-"'habited part of the town. The experiments prove "'that it was essential to go as far as Barking Creek, "'and also, as regards the level of the discharge they "'demonstrated that it should take place at or as "'near high water as practicable.' Now, although "it is desirable to fix the place of discharge as far "below the metropolis as possible, it will be found "that a practical limit to it is imposed by the neces-"sity of maintaining sufficient fall in the sewers to "keep them clean, and at the same time of pre-"serving as a safety valve, a discharge into the river "at low water by gravitation in case of accident to "the pumps as well as during excessive floods. It "must be borne in mind 'that the delivery of the "'sewage at high water into the river at any point "'is equivalent to its discharge at low water at a "'point 12 miles lower down the river, therefore, the "'construction of 12 miles of sewer is saved by dis-"'charging the sewage at high instead of at low "'water.' The position selected is Plumstead "Marshes, and the period of discharging the sewage "into the river would be from two to four hours "nearest to high water. The amount of sewage pro-"posed to be intercepted from the more closely in-"habited districts has been estimated upon data, "which makes provision for the increase of future "generations. Thus, where the population as at "present existing exceeds 30,000 to the square mile, "the actual numbers are estimated for, and where it "is less, allowance has been made for that number, in "order to provide for future increase. The supply "of water per head has been reckoned at five cubic "feet per diem, being on a more liberal scale than "now actually obtains, and of this quantity it is con-"templated that one-half will pass away during six "hours of the day. For reasons more fully set forth "in former reports, it is proposed in the urban dis-"tricts to intercept a quantity equal to a quarter of "an inch of rain in 24 hours running off, which is at "the rate of about one hundredth part of an inch per "hour, any excess beyond that amount falling on "occasions of heavy storms being discharged into the "river by the drainage sewers. With a view to "economy by the reduction of the sizes of the sewers "as far as practicable, it is now proposed to continue "the drainage of all those portions of the suburbs "which are not likely to be built upon for many "years to come into their natural valley outfalls, and "where building has already commenced, and is "likely to be extended to provide for an increase of "population, varying from 10,000 to 20,000 to the "square mile, instead of 30,000. It is further pro-"posed from the more thinly peopled suburbs to "carry off by the intercepting sewers only one half "of the quantity of rain water for which provision is "made in the more crowded districts."

12,904. Then, as a matter of fact, in that report of 1856, you considered both the range and the period of oscillation?—We did.

12,905. Now I will go to Question 12,637, in which "you were asked "I should like you to tell me if you "could of any report in which you have dealt with "the question of dilution and oxidation prior to this "Commission" to which you replied "I will ask "leave to produce them by-and-bye;" can you pro-duce them now?—Yes, in the Report of Messrs. Bidder, Hawksley, and Bazalgette, dated April 6th 1858, on page 66 this is stated: "For the proper "understanding of the reasons for our final recom-"mendations, it is necessary that we should draw the "especial attention of the board to the results of the "investigation we have caused to be instituted by "Dr. Letheby, to whom (on account of his eminence "in chemistry, his knowledge of medicine, and the "personal interest he has taken as the medical officer "of the city of London, in all that concerns the "health of the metropolis) we have thought it right "to commit the hygienic portion of our inquiry. We "have also considered Dr. Letheby not the less fit to "assist us, because he commenced the investigation "under the known influence of casually acquired pre-"possessions, adverse to some of the views to which

*Sir J. W. Bazalgette.*

22 May 1883.

" we had been led by our own observations on tidal " rivers, made in many previous years, and in many " parts of England and the continent, as well as upon " the River Thames during the period in which its " physical condition has become the subject of public " complaint. From the results of our own practice " and experience in hydraulic engineering, and par- " ticularly in reference to the drainage of towns and " the utilization of the products of sewage, we have " long been aware of the important fact that those " organic matters which are commonly received from " the domestic drains into the street sewers, and are " there acted upon by water and air undergo changes " and decompositions not necessarily of a putrefactive " character, but in the course of which they either " become resolved into their original elements or " become combined into new forms essentially differ- " ent from those in which they had originally " existed. These changes are effected with great " rapidity, so much so indeed, that it is rare to find " in the waters discharged from the sewers of a large " town any of those rich fertilising agents it has been " the object of so many endeavours to obtain; " fertilising agents of a class which, if they could " continue to exist and act in combination with " flowing water as they observedly exist, under other " circumstances would engender nuisances of a cha- " racter most prejudicial to health and intolerable to " the senses. The elements of the organic com- " pounds which are found in the excreta of towns are " all essentially pure and inocuous. It is only the " condition and proportion in which they become " united in effete matter that communicates to such " matter its disagreeable, or it may be poisonous, " properties. Sulphuretted hydrogen is a deadly gas " largely evolved from excrementitious matter whilst " passing through the process of putrefactive decom- " position. But hydrogen, one of the two elements " of this deadly gas, constitutes a ninth part by " weight of the water we not only drink with " impunity, but know to be in a thousand ways " essential to animal and vegetable life; whilst " sulphur, the other element, is in its natural state a " perfectly inert substance, incapable by its presence " of producing any injurious effect on the vital " economy. So hydrogen and nitrogen, the latter a " gas which constitutes four-fifths of the atmosphere " we breathe, and both of them inodorous, combine " together to form ammonia, the pungent basis of " many of our most valuable manures, and this again, " in union with sulphuretted hydrogen, is a most " noisome emanation from the fæcal matter trans- " mitted to the sewers. If the excreta then could " continue to exist as such, and could undergo the " same process of putrefactive decomposition after " being conveyed into the drains, as we know would " otherwise result, our sewers and rivers would on " the one hand, have long since become cesspools of " the most offensive and deadly description, while on " the other hand, the manufacturers of fertilising " compounds would have experienced no difficulty in " recovering the rich products of animal existence " for which they have hitherto sought in vain. We " feel assured, however, from the facts before us, " that so soon as the refuse of life has become " thoroughly blended with water, chemical changes " of the most important character become gradually " effected by the oxygenation (*without putrefaction*) " of some, if not of all, the combustible elements, and " the consequent decomposition and arrangement of " the other elements into inorganic forms nowise " injurious to the health of animated beings. Hence " it is that the substances which enter into a " sewer are either not to be found at its mouth, or " are only to be there obtained in a much altered and " scarcely recognisable form. And hence, too, it is " that the admission of foul organic matters into our " streams and rivers fails to render them permanently " impure or sensibly injurious. This beneficient " process of nature is indeed gradual, and to a " certain extent undoubtedly dependent on the " volume and the quality of the water into which the " dejecta are received. Observation, however, has " satisfied us that when sewage water of ordinary " strength becomes intermixed in a flowing stream " with 10 or 12 times its own volume of fresh or " freshened water, it ceases to have any tendency to " run into putrefactive decomposition, and is finally " 'consumed' by the oxygen with which one or " more of its elements enter into purifying combina- " tion. We have examined the River Mersey, which " flows from Manchester, Stockport, Bolton, Bury, " Rochdale, Oldham, and numerous other of the " important manufacturing and densely populated " towns of Lancashire and Cheshire; the River Aire, " which flows from Leeds, Bradford, Halifax, Hud- " dersfield, and other towns of the West Yorkshire " manufacturing district; the River Don, which " flows from the crowded towns of Sheffield and " Rotherham, and yet becomes pure enough to be " drank at Doncaster; the River Soar, which for- " merly quitted Leicester of inky blackness, and yet " became beautifully pellucid and full of fish and " vegetation before its arrival at Loughborough; and " in all these instances we have remarked with " wonder the rapidity of the oxidizing process by " which nature causes the disgusting feculæ of towns " to become resolved into pure and inoffensive sub- " stances. The valuable analytical researches contri- " buted to the Referees' Report by Dr. Hofmann and " Mr. Witt, afford scientific evidence of the accuracy " of the conclusions derived from the study of the " phenomena of observation. At page 8 of their " Report, the referees with another object compile " from the results of Dr. Hofmann and Mr. Witt, " the following remarkable table exhibiting the con- " dition of the river at six places, commencing at " Kew Bridge *above* London, and terminating at the " Victoria Docks *below* London." Then the table gives the organic and mineral compounds at Kew in river water to be nearly 25—24·9 grains per gallon; at Fulham, 22; at Wandsworth, 26; at Westminster Bridge, 25½; at London Bridge, 25·8; at Victoria Docks, 27; the mean being 25 grains per gallon. Then the Report proceeds:—" Now from this table " it is manifest that the organic matter nowhere much " exceeds 2 grains in a gallon = $\frac{1}{3500}$th, and that " it is of nearly the same amount in all parts of the " river between the points named, at London Bridge " as at Kew; this amount being in itself very small " and scarcely in excess of the quantity of organic " matter to be found in the waters of nearly all tidal " rivers, and in many non-tidal rivers, whether flowing " from peopled or uninhabited districts." " Dr. Taylor " the eminent analytical chemist, in his examination " before a Committee of the House of Commons on " the Metropolis Water Supply."

(*Chairman to Mr. Norman Bazalgette.*) Does not this, which has been already read by Sir Joseph Bazalgette, sufficiently answer your question?

(*Mr. Norman Bazalgette.*) The object of the cross-examination was to show that Sir Joseph had not sufficiently considered these questions before he designed the main drainage.

(*Chairman.*) But does not this extract show abundantly that he did consider it?

(*Witness.*) There is very little more to read.

12,906. (*Mr. Norman Bazalgette.*) Will you go to the conclusion?—I will. " Our own experience had " informed us not only that it is extremely undesir- " able in a sanitary point of view to cause sewage " matter to become intermixed with sea water, and " especially under circumstances which will occasion " it to be brought up the river by the flood tide, but " that if the sewage matter were poured into a " much larger volume of fresh or freshened water " in a flowing stream, it would become immediately " oxygenized and cease to exist as a noisome and " offensive agent. The experiments of Dr. Letheby " and Dr. Odling have fully confirmed our views. " We have therefore unhesitatingly selected for recom- " mendation as points of outfall, places situated in

" approachable situations as near as possible to the " metropolitan boundary and as far as possible from " human habitations. Barking Creek on the north " side, and Crossness Point on the south side, fulfil " all the favourable conditions that are attainable " on either side of the river. Both are situated in " low and dreary marshes where neither the works " nor the sewage can give reasonable cause of offence " to anyone. Barking Creek is about 2 miles from " Woolwich and about 4½ miles from Erith. Cross- " ness Point is midway between the two places and " about 3¼ miles from each. The mean sectional " area of the river at these places is four times as " great as at London Bridge, and the average volume " of tidal water about 400 times as much as the " volume of the sewage water to be admitted into " it. The river is fresh, or nearly so, at low water, " and only moderately mixed with salts of marine " origin at high water, more so, it is true, than we " could wish, but much less so than at any point " lower down the river."

12,907. Now, you have told us that in coming to these conclusions you were also guided by the report of Dr. Letheby, which is contained in the appendix to your report; his conclusions are contained on page 116?—Yes. He says, " As an example of the " injurious effect of this mud on one hand, and of " the rapidity with which the soluble organic matter " of the Thames becomes inocuous on the other, I " may mention that in the course of my inquiries " into the state of the water in the docks of London " I have remarked that all the docks on the northern " side of the river which receive their water from " the Thames below Blackwall are never offensive. " It may be that they are not so crowded with ship- " ping as the London and St. Katherine's Docks, and " therefore do not receive so large an amount of " putrescible matter; but, be this as it may, the " water in both of the last-named docks is always " turbid, and in the summer time is offensive, from " the putrefaction of the mud. All organic life has " long since disappeared from it, except perhaps the " infusorial life which swarms everywhere. It is " not so, however, with the docks lower down the " river. At the West India Dock, which comes next " in the course of the stream, the water is compara- " tively pure, and it is generally well stocked with " fish. In the summer time, however, the mud even " there undergoes putrefaction, and kills the fish. " At the East India Docks the water is still purer, " and it is a rare circumstance for the mud to putrefy " and the fish to be killed, while at the Victoria " Docks the water is as clear as it need be, and fish " of all kinds are abundant in it. The mud never " decomposes, nor does the water ever show the least " sign of putrefaction. Now, in all these cases the " supply of water is from the river at certain periods " of the flowing tide, and it would appear that if the " organic matter of the soluble or insoluble part of " the London sewage is the cause of the mischief " observed in the London and St. Katherine's Docks, " this matter is completely inocuous by the time the " water containihg it reaches Blackwall. It is not " that the proportion of the organic matter decreases, " as will be seen by the tables, but its condition is " altered. This is, no doubt, occasioned by the " action of the air, and by the agitation of the run- " ning stream, and the fact is amply demonstrated " in every river in the kingdom, especially in those " which receive the sewage of large towns. Those, " therefore, who have looked upon the soluble sewage " of London as an unchangeable log of wood floating " up and down the river with the movements of the " tide, have taken a very erroneous view of the " thing, for so prone is the organic matter to undergo " change and to complete its course of putrefaction, " that it is doubtful if it exists as a putrefying body " a few hours after its entrance into the river. In " fact, while it has been traversing the sewers it has " generally been so much agitated and broken up by " the movements of the current as to be in a very " advanced state of putrefaction. Almost the whole " of the nitrogen has become changed into ammonia, " and its sulphur into sulphuretted hydrogen, and " then, when it reaches the Thames, it finishes the " last stage of its putrefactive career by the rapid " absorption of oxygen, and the formation of com- " pounds that are comparatively inert, so that, partly " by means of dilution and partly by the destructive " powers of oxidation, the Thames possesses the " means of self purification, which is fully equal to " the contaminating injury to which it is at present " exposed." And Dr. Letheby concluded his report by saying, " I am even of opinion that the discharge " of the sewage into the river in such a way that it " would be diluted with not less than 200 or 300 " times its bulk of water during each tide, and in such " a manner that the insoluble portions would not be " deposited on the banks, would be a safe and suffi- " cient means of disposing of it."

12,908. Now I will ask you one question upon that. My learned friend, Mr. Webster, this morning put it to you that 200 or 300 times its bulk was unpolluted water; was Dr. Letheby, when he wrote that, speaking of its dilution with Thames water?—Yes; his fourth conclusion is, " or by discharging the " sewage into the Thames in such a manner that it " will mix with and be diluted by 200 or 300 times " its bulk of water."

12,909. (*Sir John Coode.*) That is water fresh and tidal?—Yes, that is water which is in the Thames; he alludes to the Thames specially.

12,910. The proportion of fresh and tidal varying according to the hour of the day?—Yes.

(*Chairman.*) Will you allow me to ask you this, if the sewage goes up the river above Barking, and then you discharge into the mixture, and then that goes up, and then you discharge again into the mixture, and so on (I am not arguing the point), can that be said to be discharging into 200 times its volume of " water," the first discharge would be so, no doubt, but on the second occasion you would, would you not, be discharging into the mixture?

(*Mr. Bidder.*) Would that not depend, my Lord, upon whether the first discharge had or had not been got rid of?

(*Witness.*) If you take Dr. Letheby's report, you will see he shows that this process of oxidation goes on with great rapidity.

12,911. (*Chairman.*) Do not suppose I am arguing, I know nothing about it, but take it that you discharge at the beginning of the springs, some of that discharge as I understand it, will be carried above the point of discharge at the next high water, then you discharge into the mixture which is worse than it was before, and then some of that will be above the outlet at the next high water, then you discharge into that worse mixture, and so on; do you see what I mean?—I hope before the inquiry is finished to show that that sewage which was discharged is not a mixture, but has been destroyed, and has ceased to exist before the additional sewage was cast in.

12,912. (*Sir John Coode.*) That is to say the sewage which was discharged yesterday is not sewage to-day?—That taking the sewage which is discharged into the river each day, the water which comes in from the sea on one tide is sufficient to oxidize each day what is coming down that day.

12,913. (*Mr. Norman Bazelgette.*) Taking the population at the present time and the water supply, and the average discharge upon an ordinary ebb tide, what is the amount of dilution at the present moment?—Taking Mr. Baldwin Latham's estimate of the popu- lation for this year, 1883, and multiplying it by the water supply, we have 9,690,000 cubic feet of sewage discharged daily into two ebb tides containing 2,233 million cubic feet of water.

12,914. (*Sir John Coode.*) Is that at neap or at spring tides?—At mean tides. Nine millions divided into 2,233 millions gives you in round numbers a didution of 1 in 230, so that we have complied with

*Sir J. W. Bazalgette.*

22 May 1883.

what Dr. Letheby said was the proper amount of dilution to effect purification.

12,915. (*Mr. Abernethy.*) That calculation is all based upon an ebb tide?—Yes, upon an ebb tide.

12,916. (*Mr. Norman Bazalgette.*) I will go next to Questions 12,644 and 12,645, my learned friend Mr. Webster, speaking of oxidation, says—"But to "what extent it would operate you do not recollect. "whether it was put down as a question of time or "volume," and your answer was—"It was both. "(*Q.*) I know in general terms, but taking the "volume you had to deal with, to what extent. "(*A.*) Speaking from this distance of time I cannot "give you the figures," I believe by reference to Dr. Letheby's Report you can give us the figures, it is at page 116 in the Report you have just read. I think you will find the answer there?—That I think I have answered already by quoting Dr. Letheby's Report.

12,917. Then we will pass on to Questions 12,647 and 12,648. "(*Q.*) And having gone into it in that "way I should be glad to see any report which would "embody the effect of your inspection. Did you at "all deal with the question of the solid matter. I "have no doubt you did. (*A.*) We did. (*Q.*) Did "you form an opinion as to what were the solid con- "stituent parts of the sewage going into the Thames. "(*A.*) Yes." You are going to read us the opinion you formed as to the solid constituents of the sewage going into the Thames?—At page 74 we reported, as follows: "In considering the causes of the turbidity "of the Thames it should be remembered that the "amount of solid matter of every description which "is poured into the Thames by the London sewers is "a comparatively insignificant quantity, certainly not "greater than 250 tons a day, a quantity scarcely "scarcely exceeding that which is cleared out of the "docks by manual labour only. The mud incident "to the Thames as a tidal estuary is largely in excess "of the mud projected into the Thames by any "population on its banks; the former is permanent, "whilst the latter is perpetually undergoing destruc- "tive decomposition. Supposing, however, as an "extreme illustration, that the sewage mud is in- "destructible and that it takes 50 days to escape to "Gravesend, it would there find itself intermixed "with a volume of water no less in quantity than "250 millions of tons, so that only one-20,000th part "of solid matter (*i.e.*, 12,500 tons in 250,000,000 "tons) would at the expiration of 50 days become "intermixed with the river water between London "Bridge and Gravesend, or (supposing that there "were neither deposit nor decomposition) 2 ounces "of insoluble matter would remain in a ton of "water. Nothing, therefore, can be more erroneous "than to suppose that the opacity of the river is "an indication either of its unsanitary state or of a "condition produced by the admission of sewage "mud. The experiments of Messrs. Hofmann and "Witt, relied upon by the referees, demonstrate "that the Thames at Kew Bridge contains as much "organic matter as the Thames at London Bridge, "although everyone may observe that the water at "Kew is nevertheless much clearer than in London. "In many rivers besides the Thames (the Nile for "one example, the Humber for another, and the "Elbe for a third) whilst the opacity is excessive, "the chemical purity of the upland water is attested "both by experiment and use." Now at that time we calculated the solid matter at 250 tons a day.

12,918. Was that for the then population?—No, prospectively.

12,919. Dr. Tidy, I think, put it for a population of 4,000,000 at the present time at 294 tons?—Dr. Tidy, in answer to questions 10,422 and 10,437, for a population of 4,000,000, estimated the dry matter in fæces at 97 tons per day, and the urine at 197, or 294 tons a day altogether, that would have been a little in excess of our estimate, if you take the dry matter in urine as forming a solid deposit. Messrs. Bazalgette, Law, and Chatterton, in their Report upon the Thames, of the 15th April 1878, estimated the total solid matter discharged into the River Thames from 120,000,000 gallons of sewage, assuming 23 grains of solid matter to the gallon at 176 tons per day. Dr. Tidy, in answer to question 10,342, gives from 23 to 25 grains per gallon as the quantity of solid matter in normal sewage, showing that our estimate of the 250 tons was in excess.

12,920. (*Sir John Coode.*) When you spoke just now of prospective population, may I ask prospective for how long; you calculated, I suppose, a certain increase of population over a certain period—what was that period?—The population that we looked forward to was 3,500,000.

12,921. Taking both sides?—Yes.

12,922. And it was at that time how much?—I think about 2,500,000.

12,923. (*Mr. Norman Bazalgette.*) I think you told us the other day, that in consequence of the more even distribution of the sewage which you discovered from subsequent experiments takes place, you find you have room for a larger population than you anticipated at that time?—We have. A great deal of my cross-examination has been tending to show that the intercepting sewers are not sufficient, that the population has increased, so that they have now become too small. That is not the fact. On the contrary the intercepting sewers are not filled with sewage to the extent that we contemplated; for although the population has now exceeded what we contemplated, the rate of flow is so much more equalised that the quantity flowing in them does not come up to what we provided for.

12,924. (*Sir John Coode.*) What ratio does the one bear to the other?—I am just going to show you.

12,925. Did you not explain this to us before?—I think not. I am now going to tell you what has happened since we last met. We have three outfall sewers upon the north side, which take the whole of the sewage of the north side, and our estimate was, that when our maximum was attained, with a maximum flow of sewage, those three sewers would be half filled with sewage, that is to say, the sewers from Abbey Mills to the outfall. Now I am going to give you a fact that will be better than all the theories and reasonings upon which we might spend the day. My calculations, as I say, showed that these three sewers during the time of maximum flow should be half filled with sewage, and the other half should be left for the quarter or eighth of an inch of rain. I took the maximum flow of sewage to be double the rate of ordinary flow, but it is not that I said, if you double the rate of ordinary flow.

12,926. (*Chairman.*) By "ordinary" do you mean "average"?—Yes, the average. If you double the average flow at a certain period of the day, during that period my sewers would be running half full; that was what I believed would be the case, but upon the 15th, and from the 15th to the 19th of this present month of May, I had occasion to divert the sewage from one of these three outfall sewers, and to let two sewers do the duty of the three, and I for those days carefully watched what was the highest point to which the sewage rose; it was dry weather, it must be remembered. I turned the high level into the middle level, and when the two supplies were going through one sewer, it rose, (the sewer being 9 feet high) to 5 feet 2 at the maximum, and it rose in the other—there is some communication which equalised it a little, but not altogether, to 3 feet 10. Now the quantity flowing through those two sewers at the time, instead of being half, was only one-third, of what the sewers could carry off, in fact, I could now put the whole of the sewage of the north of London into one of those three sewers, and it would carry the whole away, and I have two-thirds of my capacity left instead of a half as I contemplated.

12,927. (*Mr. Lumley Smith.*) That is assuming no rain?—Yes, assuming no rain. As I said I contemplated the sewage running probably about 2 feet 6 at the bottom of this 9 foot sewer ordinarily,

but at the maximum flow I contemplated its rising up to fill them half fall; it does not do so, it only rises up to fill them one-third, and the consequence is I have two-thirds still left for increase of population and rain; and these sewers are large enough to last, at any rate, to the end of the present century.

12,928. (*Mr. Norman Bazalgette.*) Now I will go to question 12,668 where my learned friend Mr. Webster puts it to you in this way, "Now will you "give us in the shape of a table, or some how or "other, how often, or over what period, sewage has "been discharged from the high level, and the lower "level, that is to say, from the northern and the "southern outfalls respectively, after high water," to which you replied "We have discharged up to four "hours after high water, and sometimes we have "been obliged to discharge before the beginning of "ebb tide, that is to say, in a flood, when you have "heavy rains." And then at question 12,697 you were asked, "I am afraid I want it a little more in "detail if you will give it me. I presume a record is "kept of the discharge?—(*A.*) Yes. (*Q.*) There "can be no difficulty in putting in a tabulated statement "for, say, the last eight years, the hours of the out-"pouring or letting out of the sewage upon the north "side, and the south side respectively?—(*A.*) I do "not think there would be any difficulty about that. "(*Q.*) Would you also kindly show upon that table "the instances in which it began before high water, "and of course, the duration of it; in all other cases "I presume it began at high water?—(*A.*) Yes." Have you now got such a table?—Yes, I have. I now put in that table, and I should like, in putting it in, to give some explanation of it. (*The witness handed in the following table*).

TABLE A.

TABLE showing NUMBER of DAYS on which OVERFLOW before HIGH WATER occurred, and their duration at CROSSNESS RESERVOIR, in consequence of the insufficient Size of the Reservoir or Heavy Rainfalls, from 1875 to 1882, inclusive.

| Years. | Number of Days on which Overflows occurred. | Duration. |
|---|---|---|
| 1875 | 144 | 14 days. |
| 1876 | 135 | 11 „ |
| 1877 | 234 | 20 „ |
| 1878 | 253 | 22 „ |
| 1879 | 290 | 31 „ |
| 1880 | 195 | 15 „ |
| 1881 | 192 | 12 „ |
| 1882 | 153 | 9 „ |

From 1875 to 1879, inclusive, the sewage was discharged for three hours, and subsequently for four hours, after high-water.

TABLE B.

TABLE showing NUMBER of DAYS on which OVERFLOWS before HIGH WATER occurred, and their duration at BARKING CREEK RESERVOIRS, in consequence of the insufficient Size of the Reservoirs or Heavy Rainfalls, from 1875 to 1882, inclusive.

| Years. | Number of Days on which Overflows occurred. | Duration. |
|---|---|---|
| 1875 | 78 | 10 days. |
| 1876 | 77 | 10 „ |
| 1877 | 144 | 17 „ |
| 1878 | 157 | 18 „ |
| 1879 | 258 | 33 „ |
| 1880 | 212 | 27 „ |
| 1881 | 244 | 27 „ |
| 1882 | 223 | 29 „ |

The discharge of sewage on the ebb tide varied from three hours in 1875 to four hours in 1882.

(*Witness.*) The above table thows that on the south side the number of occasions on which overflows took place upon the flood tide owing to the reservoir being too small, and from rain, varied from 135 days up to 290 days.

12,929. (*Sir John Coode.*) Are those overflows from the reservoir, or from the outlets?—Those are overflows from Crossness reservoir upon the flood tide. You can judge of the periods, or the length of time, by seeing how many days of 24 hours it works out into; this shows the number of actual days and calculated days of 24 hours each.

12,930. (*Chairman.*) An overflow before high water occurred on 144 days and lasted during 336 hours?—That was in the year 1875, equal to 14 days of 24 hours. Now upon the north side it was doing it on fewer occasions but for a longer period.

12,931. (*Sir John Coode.*) Before you leave the south side, we all know that 1882 was a wet year, and how does it happen that the overflows were only at work for nine estimated days?—It puzzled me at first, and I will explain it. I discovered that by seeing that if you take the north side, that is not so; that I was very much struck with myself, but if you turn to my table of the discharge at the Deptford Creek, you will find that I have to give you an account of an excessive discharge at Deptford Creek. At Deptford Creek in 1881 and 1882 it jumped up from 21 to 36, 37, and 39, for reasons which I have to explain to you. It is quite clear that you cannot have it at both places,—we let it out at Deptford Creek, therefore there was less went down to Crossness,—that is the explanation, though it puzzled me at first.

12,932. (*Chairman.*) But allow me to suggest that you get out of one trouble into another; because it is much worse for you to discharge your sewage at Deptford Creek than at Crossness?—Yes; but I explained how we discharged at Deptford Creek,—we had had an action brought against us, and I mentioned that our man there let it out improperly. Then another question asked me was, for how long we discharged; we had been discharging upon the north side for four hours, and upon the south side only for three hours, and within the last year or two I gave the order that both should discharge till four hours after high water, and we are now discharging up to four hours after high water until we get our reservoirs enlarged, so as not to have so many overflows as we have had upon the south side before the period of high water.

12,933. (*Sir John Coode.*) Then you have ceased discharging at two hours below low water?—Yes, we have until we get our new reservoir.

12,934. But how long has that been so?—Upon the northern side it has been so for years, and upon the south side since 1879.

12,935. How are we to reconcile that with the statements which have been made to us about the discharge having been seen to be going on just immediately before high water. I think we were told, on one occasion, an hour before high water?—Those are the occasions given in this table.

12,936. That was because of the overflow?—Yes, our reservoirs not being large enough.

12,937. That is the explanation of the sewage having been seen to be flowing into the river just before high water?—Yes.

12,938. (*Mr. Lumley Smith.*) But we have no return of the number of times or hours upon which the flow has gone on after the four hours?—At no time after the four hours; always at the end of the four hours we have closed the penstocks.

12,939. (*Sir John Coode.*) That has been the order, but has that been done?—It has been done; there was a leakage at the Barking Outfall, but as soon as we discovered it we remedied it.

12,940. (*Mr. Norman Bazalgette.*) My learned friend, Mr. Webster, was asking you about the occasion when the sewers rose, so that building operations

*Sir J. W. Bazalgette.*

22 May 1883.

at Paddington had to be stopped. At Question 12,722, you were asked, "Do you remember the "quantity of rain that fell?" and you replied, "Yes, "it was something very heavy. (*Q.*) Have you a "record of it? (*A.*) Yes, I have, but not here. "(*Q.*) Would you mind bringing us that here upon "the next occasion? (*A.*) You are referring, I pre- "sume, to Mr. Whitehead's premises"?—I have no record, except the record which I have put in, which is the register at Kew.

Examined by the COMMISSION.

12,941. (*Chairman.*) I wish to ask you some time or other, if you do not think it an unkind question. Is the river in a satisfactory state between Erith and Greenwich?—I think it is.

12,942. You do?—I do.

12,943. And there is no fair ground of complaint?—I think the statements which have been made have been very much exaggerated. Having regard to the position of the river and the locality, there is nothing to complain of.

12,944. When you say the "position of the river and the locality," I do not understand you; do you mean considering it has the misfortune to be so near a great town like this?—I mean that the site of the outfall is in a neighbourhood where there is no population, where there are chemical works, and which, according to my view, is a suitable place for an outfall to be; no harm really is occasioned by the discharge of sewage there.

12,945. I do not think that is quite an answer to my question; your answer seems rather this, that it does not matter that the river is not in a very satisfactory condition. But I would rather ask, Is it in a satisfactory state?—Of course, at the outfalls, you will find sewage, but I think very quickly it gets diluted and destroyed by the water of the river, and that by the time you get a mile or two from it you cease to find it.

12,946. And you say that it is no serious inconvenience either to the health or comfort or the enjoyment of the people who live upon it, or upon its banks?—I think not. I have heard it said that people were poisoned who were drowned by the accident to the "Princess Alice" just above the outfall. I have seen the water taken out of the Thames at that spot in a glass, and I have seen a gentleman in this room drink it, and there was nothing offensive in it.

12,947. (*Sir John Coode.*) But do you recollect that this was the hottest period of the year, and in a dry season when this happened?—It was in the early part of September. Then we have heard about the mud banks being so bad; now there are honourable members of the Commission who have been down with me to Crossness, and landed upon the shore, and walked upon the shore where it was as clean as this floor.

12,948. (*Mr. Abernethy.*) That was a very limited section of the shore?—It was all round the outfall. I have sat here and listened with astonishment to the statements which have been made by gentlemen living down the river. I have been down the river and have never been able to discover anything offensive until you get close to the outfalls.

12,949. (*Chairman.*) How near would you call close?—I think it was the observation of the Commission that when they got three-quarters of a mile below the outfall the unpleasantness had ceased.

12,950. And it was better above?—Yes, better above. I can only say that if you will give me the 4,000,000*l.* that would be expended upon this suggested work to expend upon other works in London I could lay it out much more for the benefit of London.

12,951. Do you estimate it would take 4,000,000*l.* to carry the outfalls further down?—Yes; that is the estimate I gave you, taking the working and expenses of pumping capitalised, and I say that money could be expended very much more for the benefit of London than by doing what has been suggested.

12,952. The sewage could not be utilised upon the Maplin Sands, or anything of that sort?—I should have been glad to have seen that scheme tried, but unfortunately it became a failure.

12,953. (*Sir John Goode.*) When you say the money could be better utilised, do you mean better utilised in the way of treating or disposing of the sewage, or in some other direction?—His Lordship was referring to a scheme which proposed to utilise the sewage upon the Maplin Sands.

12,954. But you said, before his Lordship put that question, that if the 4,000,000*l.* which would be necessary to change the position of the outfalls had to be expended, it could be utilised in some better way than by changing the position; did you mean by utilising the sewage or giving improved water supply or what?—I meant that there are other works upon which that money could be laid out. I say that if that money were expended, first in relieving London from floods; next in the that works we propose to lay out money upon, and lastly, in making communications across the Thames below London Bridge, that money would be expended very much more to the advantage of those living in London than it would be expended by the extension of these works to a more distant point of the river.

(*Mr. Bidder.*) Would your Lordship ask Sir Joseph this question. Assuming that the outfall was moved further down the river to some other place nearer the sea, whether there would or would not be the same amount of local effect or nuisance, if you please to call it so, at the new outfall as there is at the present one.

12,995. (*Chairman.*) I will ask Sir Joseph, but we know his answer beforehand, I think, because he would probably say there would be more water for the sewage to fall into?—It would fall, moreover, into salter water, and the more salt the water the greater the liability to create nuisance.

12,956. I suppose there are places upon both shores upon which there is scarcely any population at all, are there not?—Not upon the Thames.

12,957. But if you take the inlets—take the Maplin Sands themselves?—That is out of the Thames; it is right upon the Essex coast.

12,957*a*. (*Chairman.*) But how far would the 4,000,000*l.* take you?—I was contemplating going below Gravesend then. I was thinking of going to Higham Marsh and Tilbury; my estimate was 2,000,000*l.* for sewers, 300,000*l.* for reservoirs, say half a million for engines and building, and 50,000*l.* a year as the annual cost of pumping capitalized, making another 1,000,000*l.*, that is 3,500,000*l.* in round numbers.

12,958. (*Mr. Abernethy.*) Was not there an Act of Parliament obtained to carry the sewage down to the Maplin Sands?—There was, and the works were commenced; the Maplin Sands scheme did not propose to take the whole of the sewage of London away; they proposed, I think, one outfall sewer with a pumping station, the sewer to be 10 feet in diameter.

12,959. (*Sir John Coode.*) Did they propose to take all upon the north side?—No, they proposed to take as much as suited them, to use their reservoir, and to let the surplus go into the river.

(*Mr. Lumley Smith.*) Would your Lordship allow me to say that with regard to this, which is new matter, we rather understood the wish of the Commission to be that we should deal with the state of the Thames as it is.

(*Chairman.*) Yes, that is quite so, but the one or two questions which have been asked are not of any very great consequence; indeed Sir Joseph volunteered the observation about the 4,000,000*l.* himself.

The witness withdrew.

[Mr. George Chatterton called; examined by Mr. Bidder.

12,960. You are a civil engineer and an Associate Member of the Institution of Civil Engineers?—I am.

12,961. You have been professionally engaged for some years past in observations, taking soundings and sections on the River Thames, have you not?—I have been engaged on the Thames since May 1877 very frequently.

12,962. And particularly, may I take it, in the neighbourhood of the metropolitan outfalls?—I have been engaged more particularly in the neighbourhood of the metropolitan outfalls.

12,963. You say since May 1877, at that time I think you were employed in taking sections in Long Reach?—I was employed in the early part of May taking soundings in the river at Long Reach at a little below Purfleet, opposite the West Kent outfall.

12,964. (*Chairman.*) Employed by whom?—By the West Kent Main Sewerage Board. I was then their assistant resident engineer.

12,965. (*Mr. Bidder.*) That was with regard to the scheme that was then pending, and afterwards sanctioned by Parliament, was it not?—No, we were then carrying out the scheme.

12,966. Quite independent of the metropolitan sewage?—Yes, it is quite independent of the metropolitan system, they have an outfall of their own.

12,967. Where is their outfall?—Their outfall is near a place called Little Powder Creek in Long Reach.

12,968. A little below Dartford Creek?—A mile below where Dartford Creek discharges into the Thames.

12,969. At that time for this purpose you were taking soundings, as I understand, in Long Reach; would that be at all times of the tide?—No; you can only sound in the river during the last three hours of the ebb; immediately the flood tide commences you must give up, but in that way I had a very good opportunity of judging of the condition of the river when the sewage from the metropolitan outfalls would be passing down; it would about reach that part of the river in three hours.

12,970. Speaking of that time, May 1877, was there in the part of the river that you were engaged in in Long Reach a perceptible smell or indication of the sewage from the outfalls?—There was no smell, no perceptible smell of any kind, but there was an indication of the sewage. By watching the river very closely upon a very calm day, you could notice corks and bits of vegetable, and traces of grease, which would float upon the surface, but there was no possible means of detecting any large bulk of sewage as far as the nose or the eye could detect it.

12,971. Had you occasion to walk upon the foreshore frequently?—I had to take foreshore sections between high and low water, and that I did with long boots on, and, of course, I became practically acquainted with the mud in that business, and I never found the mud differed from ordinary Thames mud or more disgusting in smell, or in any other way than any other mud.

12,972. (*Chairman.*) That was about seven miles below the Crossness outfall?—Over seven miles below Barking.

12,973. (*Mr. Bidder.*) And six miles below Crossness?—Over six miles below Crossness.

12,974. You have been there since, recently, have you not, in the same part of the river?—Yes, I have been there every year since, and I was there a great deal last year.

12,975. Do you observe any change in the character and condition of the river or of the foreshore, comparing 1882, or your most recent visits, with 1877?—I do not think it is possible, as far as the eye or the nose is concerned, to detect any change in the mud upon the foreshore. I do not think it is altered in the slightest; there is certainly a decided alteration in Long Reach in the set of the tide. The set of the tide has altered in Long Reach in the last few years; it does not take a very skilled person to detect that. For nearly two years there has been an enormous amount of dredging taking place in Long Reach upon the north side of the river, which has deepened the river very much there, and cut a regular gut-way, you may say; and there can be no doubt that the set of the tide is a great deal more now upon the north side of Long Reach than it formerly was, but I do not think there is any accumulation of mud taking place upon the south side, and certainly the character of the mud I do not think is altered.

*Mr. G. Chatterton.*

22 May 1883.

12,976. Are you now speaking of Long Reach?—I am speaking of Long Reach.

12,977. At that time, in the months of June and July 1877, I think you were engaged almost daily in superintending the construction of the works of the West Kent Drainage system?—Yes, I was; the tanks of the West Kent system are immediately adjoining the sea wall at Long Reach, and it was my duty to be there to see that the work was being done, and I was down there all through that summer almost every day.

12,978. Those being summer months, June and July, did you observe any smell or suffer any inconvenience from any smell of the water then?—I never heard of any complaint. I never noticed any offensiveness, and I do not think it was possible for anybody upon the banks, by eye or by nose, to tell whether there was sewage being discharged at the Metropolitan Board of Works outfalls or not. We had 200 or 300 men employed at the works there at one time. I never heard a complaint from them, and they used to bathe in the river in hot weather.

12,979. Have you referred to the records of the temperature to see whether the temperature which Mr. Baldwin Latham suggested, viz., 65 degrees, I think it was, at which the river would begin to smell, was exceeded during that period?—Mr. Baldwin Latham put in a table of temperature which is taken from the Astronomer Royal's Returns and Greenwich Reports, and they are quite correct. I have gone through them myself. I do not agree with Mr. Baldwin Latham when he says that the river would become noxious at about a temperature of 65°. At Question 7414 he says: "The river would become noxious, "say, at from 65 to 70 degrees." I do not think that can be right. I think it must be something a good deal nearer 70 than 65, because, according to the tables that he put in, the temperature of 65 was reached upon 19 days in June 1877, and 25 days in July, and 30 days in August. I must say that during that June, July, and August I never heard of a complaint.

12,980. Nor noticed it?—Nor noticed it.

12,981. I do not want to go into too great detail through every month, but I think you continued for the purpose of the work you were engaged upon visiting the river all that autumn?—Yes. I may say that one part of the month of June (it is not given in Mr. Baldwin Latham's tables, but it is upon the records), I find that upon the 21st and the 23rd of June the temperature of the Thames exceeded 69°.

12,982. May I take it that the same absence of smell and perception of the sewage would apply to the autumn as to the months that you have already of?—It would.

12,983. Now in 1878 were you engaged in another investigation which took you to the banks of the river, examining them from Greenwich downwards?—Yes, I examined them with the view to see how much of the banks was being washed away; I examined the banks of the river and the saltings all the way down, more particularly upon the south side. I walked down all the banks of the river from Greenwich as far as Cliffe.

12,984. You inspected practically the banks of the river?—Yes, I went from Greenwich to Cliffe and Cliffe to Yantlet.

12,985. Now I will ask you this. To the best of

*Mr. G. Chatterton.*

22 May 1883.

your observation, would the mud which has been spoken of by witnesses from Erith, and which has accumulated at Erith Bight, differ from, or would it be similar to, the mud that has accumulated above and below?—I do not think as far as an ordinary person can detect it that there is any difference between the mud in Erith Bight and the mud at the mouth of all the creeks down the river. At Cliffe Creek there is a good deal of mud, and I do not think that any ordinary person can detect any difference between the mud there and the mud at Erith; I know I could not.

12,986. I think some witnesses spoke of the difference of colour between the mud above and the mud below; do you find that it is light above and dark below?—Yes, the general character of the mud is that it is of a light colour upon the top, and when you put your foot or rod into it it is black; it is black as far as I have examined it below Higham upon the north side.

12,987. Through that year, 1878, were you frequently upon the river?—I was.

12,988. Can you say whether your experience as to the condition of the river was the same or different from what you described in 1877?—I never found the river offensive. I never smelt the river of sewage except as anyone would, immediately up under the outfalls. I may say that I have a good sense of smell—I can smell as well as most people.

12,989. That we may know your opportunities of observation, how many times were you engaged upon the river during the year 1878?—I was 37 days engaged upon the river during the year 1878.

12,990. There is one matter I should have asked you about, I think—it was in that year that you collected the sample that was given to Mr. Keates, the late Analyst to the Board, of the fluid coming from the Beckton outfall?—I did; that was the year that the "Princess Alice" disaster occurred, and there were great complaints after that, as you have heard, and thereupon Sir Joseph Bazalgette advised the Metropolitan Board of Works to go down and see for themselves what was the condition of the river; they went down in a steamer upon the 23rd of November, and the press went with them, and Sir James Hogg invited a good many people; they went a good way down, I think as far as Gravesend, and in coming back they stopped the steamer opposite where the Princess Alice went down. I know that outfall at Beckton was discharging a very disgusting sort of tar refuse, and I went ashore and brought away a sample of it, and it rather astonished everybody there.

12,991. Was that sample afterwards analysed?—It was, but the appearance of it was quite enough to satisfy anybody. It was disgusting, it had a strong tar smell, and from its appearance it would be likely to be a deadly poison, I should think.

12,992. There was something said about a very offensive smell upon the water at the time of the "Princess Alice" accident, but I do not know whether it is within your knowledge that there was a very severe fire at some works upon the river?—There was a very severe fire, I heard, occurred that day upon the river at Messrs. Price's, I believe, but I do not know it of my own knowledge.

12,993. In 1879 were you frequently engaged upon the river?—I was engaged taking soundings a good deal that year.

12,994. Will you say at what place?—I was engaged at Long Reach taking soundings over the same lines as I took them in 1877, the temperature of the water at the time I took the soundings was 62, it was rather cold, the condition of the river was very good; that was in the month of May, and in June and July I took soundings of the river. Upon the 18th July the temperature of the water was 67·8. I have never noticed any smell in that part of the river from the sewage when I have been there.

12,995. Last summer, in 1882, you were frequently, almost daily, upon the river, were you not, collecting samples and making observotions in connexion with the proceedings before the Commission?—Last year I was altogether 59 days upon the river.

12,996. Have you gone to the outfalls and followed the sewage from the outfalls at the point of discharge, tracing it down?—I have. I have tried to estimate the nuisance, or so-called nuisance, upon the river myself, as far as it is practicable for any person who is not a chemist to do so. I have taken every means of observing the discharge of the sewage, and seeing how far it can be traced, the opportunity I was looking for was a bright, calm day; upon a rough day it is no use, you cannot see it, but I did follow the sewage down very carefully upon a fine day.

12,997. What day was that?—That was upon the 22nd May last year.

12,998. I assume you begun at the outfall. Going to the point of discharge, what do you observe at that place?—Upon the 22nd May I got to Barking about half past four, and the sewage was not being discharged at the time, but I was in an open boat and I went out immediately in front of the apron of the outfall, so that I would be in the middle of the sewage when it was discharged. When the sewage comes out first it is most dreadful, most sickening, and when you are in the middle of it you wish to get out of it as fast as you can, it is very strong—it is a smell that you never forget when you are in the middle of the black filth coming out of the outfall, but when I got in there I waited until there was a lot of sewage all round the boat, it was very black and very offensive, and I put in a float as I wanted to trace any particular portion of the sewage to see how far I could follow it, and I followed it down and took notes all the way down.

12,999. I think you started upon that journey according to my proof at quarter past five in the afternoon?—I did. I put in a float at quarter past five, immediately off the outfall and in the middle of the sewage. At quarter to six that float was abreast of the lower portion of the reservoir, moving slowly, and I took test tubes with me about a few inches long. I would fill them about half full of the sewage, or the river water whichever it was, and shake it up, and smell it to see if I could perceive any smell.

13,000. Did it smell?—Yes, when that was done near the reservoir it smelt strongly.

13,001. When did you next observe it?—I observed it next at six o'clock.

13,002. Where were you?—The boat was then off the centre of Lawes' Chemical Manure Works.

13,003. Could you see sewage upon the surface of the water then?—Yes.

13,004. What distance would Lawes' Works be from the discharging point?—It is a very short distance.

13,005.—Would it be half a mile?—It would not be half a mile.

13,006. Then I gather this was just after high water and the tide had not begun to ebb rapidly?—No, it was just the beginning of the discharge, the first of the ebb, on that three quarters of a mile below Barking outfall the float was a little to the north of mid-channel.

13,007. Could you see the sewage there?—Yes, you could detect particles of grease and bits of vegetable, you could tell there had been something discharged into the river and you could see traces of sewage, three quarters of a mile below, but mostly in the shape of floating particles.

13,008. At that point was there a smell in the air without shaking up the water?—No, there was no smell at all in the air from the water, unless it were taken up in the test tube and shaken violently, and then it did smell of sewage.

13,009. When did you next examine it?

13,010. (*Chairman.*) How came you to do this?—For the purpose of this Commission I was asked to do it. Then at one mile from Barking outfall a sample of water taken up and shaken violently smelt faintly of sewage. At a mile and a quarter the float was to the south of mid-channel, and the water smelt faintly when shaken.

13,011. (*Mr. Bidder.*) But was there any smell in the air then?—No. Then off Half Way House more than one and a half miles below Barking, the float I put in as a guide was about 100 yards from the south shore—the sewage had gone from the north shore to the south shore, and you could detect traces of sewage—the water was perfectly calm, as smooth as glass. Then before Crossness was reached, I could not detect the Barking sewage.

13,012. Neither by sight nor smell?—I could not detect it by the smell, but I could detect it by particles of vegetable, which I had known had come down, such as bits of cabbage, and potato skin, and such particles as were alongside my float all the time, having floated down, but as far as any solid particles of sewage or any discoloration generally were concerned, it was impossible to detect them, and the water, when taken up in the test tube, did not smell.

13,013. Not when shaken?—No.

13,014. Then following the ebb, you came to Crossness?—Yes, following the ebb I came to Crossness; a little below the Crossness outfall the float was 200 yards from the Crossness Quay Wall.

13,015. Did you then come into the Crossness sewage?—I was then in the Crossness sewage. Off the Belvedere Guano Works, which are between Crossness and Jenningtree Point, I was in the centre of the Crossness sewage; the water was as smooth as glass, and the wind was south, and light.

13,016. What was the condition of the river then; was there any smell?—The water when taken up in the test tube smelt when shaken, but there was no smell in the air until I got a little lower down, when there was a most abominable smell from Johnson's Fish Manure Works.

13,017. I was going to ask you this; in that part of the river you observed, did you not, some very offensive smells from a succession of factories upon the banks of the river?—Yes, but upon this day I think Johnson, as he generally does, eclipsed them all; he was very overopwering.

13,018. Now going on downwards, the next point I see is Wilson's Works?—Wilson's Works are opposite, upon the other side.

13,019. What was the condition of the water and the smell there?—You could still detect sewage from particles of vegetable floating, and little bits of grease, and that sort of thing—and in the water when shaken up you could detect a faint smell of sewage, but nothing that would cause any discomfort I should say.

13,020. Then next I think you come to Rainham Creek, or a point a little below Rainham Creek?—Yes, at a quarter of a mile below Rainham Creek, or 4 miles from Barking, the traces of sewage were visible, it was setting over towards the north shore.

13,021. Then 4 miles below Barking would be about 2½ miles below Crossness?—I call it 2 miles below Crossness.

13,022. Was there any smell there?—No.

13,023. Then you came to Coldharbour Point, what did you observe there?—Off Coldharbour Point the float I had in was about 200 yards from the north shore.

13,024. Were there any traces of sewage there?—Yes, you could detect it there of course. When I say "traces of sewage," they were acting the same part as my float was, they were bits of vegetable and small fragments of insoluble substances floating down.

13,025. Was there any smell there?—No.

13,026. Did the water smell when shaken?—No.

13,027. Then when you got to Long Reach, what did you observe?—At the upper end of Long Reach, 6¼ miles from Barking, I could detect a few traces of sewage; it was a beautiful evening.

13,028. To shorten what I have to say, I will ask you, where did you finally lose the sewage?—I finally lost all trace of it opposite Long Reach Tavern, or the "Royal Hotel," Purfleet.

13,029. (*Sir John Coode.*) Which end of the Reach is that?—That is the upper end, seven miles from Barking. It was, as I say, a beautiful evening, and in the boat I cast across, and across the river, and it was impossible to detect any trace of floating matter from the sewers.

13,030. Was all this upon the 22nd May last year?—Yes.

13,031. (*Mr. Bidder.*) If I followed you rightly you had long since lost it as far as smell was concerned, before you came to Erith?—Yes, the last time I smelt it was somewhere below Jenningtree Point.

13,032. Those traces of sewage that you were enabled to recognise down to the point you have mentioned, were the particular particles accompanying the float?—Yes.

13,033. (*Chairman.*) Where is it the witnesses say it became necessary to take the fish out of the wells?—In the summer time they say they have to take them out at Gravesend.

13,034. So that taking the fish as witnesses, they are conscious of the sewage much lower than you are?—I would not say that; I would say they are conscious of the effect of the sewage, but not of the sewage itself. I think the fish have rather a finer taste than you would imagine—the fish are in the summer time, I think, taken out Gravesend, but in the winter they are not.

13,035. They come higher in the winter time?—As far as that goes, they can come right through the outfall—the Dutch eel boats I have watched coming through the outfalls.

(*Mr. Beaumont Morice.*) One of my witnesses said that at low water fish will not live at Gravesend.

13,036. (*Mr. Bidder to the witness.*) The day you describe so fully, I gather from its calmness, was an exceptionally favourable day for tracing the sewage a long way?—I was out upon the river almost every day last year, and I never saw any day so favourable for noticing the discharge. If there is any wind at all you cannot notice it—the thing is broken up.

13,037. (*Sir John Coode.*) Have you any evidence with regard to the quanty of fresh water coming over Teddington Weir for a week or two before this month of May?—I have Mr. John Taylor's gaugings at Seething Wells.

13,038. (*Chairman.*) Speaking generally, had there been much or little rain?—I cannot remember at the present moment, but the Greenwich rainfall is given in Whitaker's Almanack, day by day for the last year. I find that upon the 22nd of May 1882, there was ·02 inches of rain fell at Greenwich, and there had been no rain since the 6th of May, therefore, there had been no rain from the 6th until the day I was there—it was rather a dry period, as there were 16 days without any rain at Greenwich. There was some rain upon the 6th, and the 4th, and the 3rd, but there might, of course, have been rain up above though there was none at Greenwich.

13,039. (*Mr. Bidder.*) Now later on, in the summer of last year, I see you were on the river upon a great number of occasions?—I was.

13,040. And you took a large number of samples, which have been analysed by chemists?—I did. I may as well put in for the Commission a plan, showing the position of those samples, as I daresay they will be referred to hereafter. This plan shows the position of the samples, and this is a cross-section of the river showing the exact spot, and state of the tide at which each sample was taken.

*The plan and section were handed in.*
*See Appendices A.K. 1 and 2.*

13,041. I see that several times in the month of June you were there?—I was.

13,042. And several times in July, the dates of which you can give?—I was.

13,043. And I will ask you this: upon those occasions did you find, excepting as you have already described, when you got into the sewage flow immediately near the outfall, that you could perceive any smell from the water of the river?—I do not think there was any smell in the Thames last year, unless

*Mr. G. Chatterton.*

22 May 1883.

you went out into the immediate neighbourhood of the outfalls, when you were not really in the Thames at all, but were in the sewage; but for a reasonable distance below Barking and Crossness, say midway between the land magazines in Barking Reach and and off Jenningtree Point in Halfway Reach, I do not think there was anything to complain of at all; there was certainly no smell from the water any day last year that I was out.

13,044. (*Sir John Coode.*) When you say there was no smell from sewage, was there no smell of any kind or description?—There were very bad smells from the factories, but when once the sewage was dispersed into the bulk of the river water, there was no smell from the Thames itself.

13,045. Do you think that you are safe in assuming that the smell that was there, was the smell from the factories, and that there was no sewage smell mixed up with it?—There was no sewage smell. I have done everything I could to detect the smell of the Thames water. I have got out of my steamer on different occasions and steamed up past the outfalls as fast as she could go, and I have got into a small boat astern, and lain down on my face and put my nose within an inch of the water. I did that on one occasion when the water was over 65 degrees. I think it was 66 degrees, and when I came into the neighbourhood of Crossness, within a very short distance of Crossness, I could tell where I was by the smell of it.

13,046. About how far?—About 250 yards off.

13,047. You could see nothing in the way of sewage until you reached that point?—I could see perhaps bits of cork, and so on, upon the surface. I knew that the sewage was being discharged; but when you pass out of the outfall again you lose the smell; it is a very easy smell to detect, and there is no way to detect it so well that I know of as in going astern of a screw in a boat; it is a very favourite way of the watermen going about on the Thames, and I have no doubt they get the benefit of it if ever it does smell when they do so.

13,048. (*Mr. Bidder.*) If the Commission were to go down in a steamer, you believe that unless it were some particularly and exceptionally hot day, they could perceive no more than what you describe?—No; what I have described is nothing exceptional; everybody admitted last year that there was no smell; the fishermen are the people who complain the most, and they admitted that there was really no smell from the water last year.

13,049. You spoke of a sample you took at the Beckton Outfall upon the occasion of the "Princess Alice" catastrophe, have you observed that the Beckton Outfall does discharge offensive matter in recent years?—I have. I noticed it discharging upon the 13th June last. I do not place much importance upon the discharge of the Beckton Outfall, except that Mr. Baldwin Latham brought out a table showing that the thing discharged very seldom, and that what it did discharge was not very noxious.

13,050. I will also ask you whether you observed anything which was noxious at that part of the river known as Bow Creek?—Yes, I was going down the river upon the 3rd of July, and I got opposite Bow Creek about 9 in the morning, and I noticed a very large quantity of sewage coming down Bow Creek at low water, and the creek itself was in a very muddy condition, the Beckton outfall was also discharging that day.

13,051. (*Chairman.*) That is upon the River Lea, is it not?—That is the River Lea, and the sewage that I noticed was the West Ham sewage.

13,052. (*Mr. Bidder.*) Have you noticed any matter discharging upon the surface of the river from any of the factories of an offensive charactor?—No, I have never been able to see any great discharge from the factories. I have seen some refuse coming out of them. I know it does come from some of the factories, but I have never been able to discover it except on one occasion, at Rainham Creek. I have noticed a good deal of refuse being pumped into the river from barges.

13,053. Do you say "pumped into the river"?—Yes.

13,054. Of what character?—It is some refuse from gasworks. I do not know exactly what it is called, but I have seen a barge go down opposite Blackfriars Bridge in the summer-time of last year. It was upon the 3rd of July, and they were pumping this stuff away into the river as hard as ever they could, and there is a lot of bilge water from the paraffin ships which is pumped into the river, that is to say leakage from the casks.

13,055. (*Sir John Coode.*) Where do you say this barge came from, that was discharging opposite Blackfriars Bridge?—It came from these gasworks, which are just above Vauxhall Bridge.

13,056. (*Mr. Bidder.*) There is another day now later on. You completed your observations on the 27th of July; I will not ask you to go through them in the same detail, but upon that day how far could you trace or detect, by smell or otherwise, the sewage from the outfalls?—I could not distinguish the Barking sewage that day much further than between the land magazines.

13,057. What distance is that?—It is exactly 1,000 yards.

13,058. Did you notice in July, because we have heard a good deal of evidence of people smelling bad smells in the neighbourhood of the river, whether the smell of the various factories was particularly bad at that time?—Yes, on some days it was very bad, in fact every day that the wind was favourable. I refer more especially to the factories below Crossness. The smell from Johnson's factory was something d. eadful; the smell from Lawes' works is occasionally very bad, but the smell from Johnson's and the fish manure factory upon the opposite side was overpowering.

13,059. Now with reference to your evidence as regards the fish, you said something about that just now, but my learned friend, Mr. Beaumont Morice, was contending that there was evidence that no fish could live at Gravesend in the summer; have you observed fish in that part of the river?—I have frequently seen them catching fish at high water opposite the Ship and Lobster, and I frequently noticed fish last year in the wells of the vessels at Gravesend at low water, and they never take them out all through the low water; they are towed up by a tug upon the flood. Upon the 7th of August last year, I went on board a Dutch eel boat called the "London Van Work." I came up with her from Long Reach right through the outfalls, and I went below and watched the fish as we were coming up through the outfalls, and they did not seem at all uncomfortable; the captain told me it was the usual thing; it was his usual cargo; he had about 15 cwts. of eels on board.

13,060. Then on the 15th of August you went to examine the river above bridge at Battersea, did you not?—I did.

13,061. Did you make an examination to see if there were important contributions to the sewage of the river below Teddington?—Yes, there is certainly a great deal of sewage discharged into the river above London Bridge; I noticed upon that day at the Chiswick outfall, where they are supposed to purify the sewage, that they were certainly neglecting it upon this occasion.

13,062. Was that discharging sewage into the river?—Yes, and very strong sewage too; our chemists were on board that day, and they took a sample of it.

13,063. Then in the month of August, and again in September, through the Autumn, did you carry on further observations in the river?—I was engaged during the whole of the latter portion of August in taking soundings at Erith for the purpose of this inquiry,—from a little below Jenningtree Point to below Easton and Anderson's works.

13,064. Shortly, may I take it that the same description substantially will apply to your observations

upon these occasions, as regards the perception of the sewage in the neighbourhood of the outfalls, and its non-perception further off?—As far as the eye and the nose are concerned, you cannot detect the sewage unless it is a calm day. You will see, even as far as Erith, traces of vegetable and other floating matter which are not offensive, but they must have come from the sewers; they simply act as floats; they are insoluble; but as far as any smell from the Thames goes, there was no smell from the Thames in Erith Bight last year.

13,065. Did you, whilst taking soundings, take means to bring up mud from the bottom in any places?—I did.

13,066. What was the result of your observations of the mud. You are aware that it has been described to us as filth rather than mud. You saw many samples of mud in these soundings, but you saw, I think, none corresponding to this description?—No. In some parts, as in Erith Bight, there is a great deal of mud, but it is mud which I should describe as being mixed with a great deal of water; it is a very soft mud, indeed.

*Mr. G. Chatterton.*

22 May 1883.

13,067. (*Sir John Coode.*) Is it slimy or clayey?—You can hardly call it slimy.

13,068. You would call it sloppy?—It is not offensive, but I should not care to work in it very much or in any mud.

13,069. Then this mud at Erith is really offensive; I gather that from your last remark?—I should not care to work in any mud; not as some of the witnesess have described, working up to their middles in it.

13,070. (*Chairman.*) There is some mud which has a sort of sedgy smell?—I do not think there is any difference between the Erith mud and the mud right away down the river or the mud right up the river. It is certainly lighter in colour at Erith than mud in the River Mole.

Adjourned to to-morrow at half-past 12 o'clock.

# THIRTY-FOURTH DAY.

## Wednesday, 23rd May 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.

FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst. C.E.

WILLIAM POLE, Esq., F.R.S., *Secretary.*

Mr. GEORGE CHATTERTON further examined.

13,071. (*Mr. Michael.*) You have some figures, I believe, to put in?—I was asked for some tables yesterday of the discharge over Teddington Weir, and I now put in some gaugings taken at Seething Wells, at the Lambeth waterworks, by Mr. John Taylor, the engineer to the Lambeth Water Company; the table also gives the height of the Thames at this place above summer level for each day. I find that there was not very much water coming down at the time. Upon the 20th of May 1882 there was 577,000,000 gallons; on the 21st there was 601,000,000 gallons, and on the 22nd there was 653,000,000 gallons; the mean daily flow here is about 833,000,000 gallons.

13,072. What is the highest?—The highest for the month of May is 1,697,000,000 gallons in the twenty-four hours.

(*The Table was handed in. See Appendix A L.*)

13,073. (*Chairman.*) This table relates to the days when you examined the river?—Yes.

13,074. I suppose the object of it is to show that there was not an unusual quantity of fresh water in the river?—Yes.

13,075. Does it show that?—It shows that there was rather a small quantity of water coming down.

13,076. I suppose you give a general answer, in the negative, that there was not an abnormal quantity of water in the river, and justified that answer by the tables?—I do.

(*Mr. Michael.*) The quantity which came over upon that day when you made your special observations, and the days immediately before, was very much less than the mean of the quantity which passes over. It was important, as Sir John Coode put it to the witness, to know the quantity which passed at that time. The mean was very much larger than on the days you have given, there was about 22 per cent. less on these days than the mean.

*Mr. G. Chatterton.*

23 May 1883.

13,077. (*Chairman to the witness.*) Those are not your own gaugings, of course?—No, I am not responsible for these gaugings in any way. I got them from Mr. John Taylor.

13,078. (*Mr. Michael.*) You were beginning yesterday to give some observations you had made with respect to the set of the tide?—I have observed the set of the tide from the outfalls down the river. I thought I might perhaps just state where my observations were.

13,079. Did you put in a float at Barking in order to see what the set of the tide was?—I have made a good number of observations. Generally, if you put in a float opposite Barking outfall at high water, it will move at first very slowly until opposite Barking Creek. It will then begin to be deflected towards mid-channel; on reaching the land magazines or 1,000 yards below the Barking outfall, it will be about mid-channel; it will then set over close to Leather Bottle point, and, having turned the point, it will move parallel to the Crossness quay wall, or river wall, until nearly opposite the Belvidere guano works, when it will set over to the Essex shore, in the direction of Coldharbour Point; it will then pass close to Coldharbour Point, which is a point upon the Essex shore immediately opposite Erith, and it will set from Coldharbour Point towards the "Castalia," the twin Channel ship which lies there.

13,080. (*Sir John Coode.*) But she may be moved; geographically, where is that?—It is in about the centre of Erith Rands. The float will then set down to about opposite Easton and Anderson's works.

13,081. (*Mr. Michael.*) If a float is put in at another part of the tide, does it take the same course?

*Mr. G. Chatterton.*

23 May 1883.

—No, a float put in at the Barking outfall from one hour and a half to two hours after high water will take the same course until it gets to Leather Bottle Point or Halfway House, but instead of taking the south shore, and parallel to the Crossness quay wall, it will go over to the north channel, to the deep water upon the north side, and pass close to Dagenham jetty, and so along the north side of Halfway Reach and Erith Reach, and follow the same course as I have described already.

13,082. From that you are able to tell how the sewage will affect Erith?—As far as Erith is concerned, Erith being in a bight, the sewage never passes straight into the bight; it always keeps the opposite side when discharged, either at Barking or Crossness.

13,083. That is equally applicable to the Barking sewage and to the Crossness sewage?—It is so; the sewage discharged at Crossness follows a parallel course to the river wall until it reaches Jenningtree Point; when it reaches Jenningtree Point, it is deflected to the Essex side, and goes along down that northern side, and passes close to Coldharbour Point, in the deep water. I have never seen a float go into Erith Bight at that time of the tide.

13,084. Have you made many observations?—Yes, I have.

13,085. (*Chairman.*) I should like to ask you this, the witnesses say there is a place where the hard has got very much covered?—Do you refer to Erith Causeway?

13,086. If I understand you, the sewage ought not to have got there?—No, the sewage cannot get there upon an ebb tide.

13,087. Have you any notion how the shoaling has been caused there?—Yes, I know it perfectly. Wherever you find slack water in the Thames for any lengthened period, you must have a deposit, because the suspended matter goes to the bottom. Now, of all parts of the river, that near Erith Causeway is in about the slackest. On an ebb tide, at three hours after high water, there is slack water there, and at three and a quarter hours, say, after high water, immediately above Erith Causeway, when you get opposite the Corinthian Yacht Club, which is above, near the church, there is a considerable eddy tide all the way up there; I should think an eddy tide at the rate of one and a half miles an hour.

13,088. (*Sir John Coode.*) Is the Corinthian Club above the causeway?—Yes, it is.

13,089. How far above? I suppose you have not the track of the currents laid down upon the chart?—Some of them I have, but Mr. Law, who is coming after me, will give you those details. I have made careful float observations there; and below Erith Pier, which is a little below Erith Causeway, there is never any tide up, so that Erith Causeway, where this accumulation of mud has taken place, lies between two currents, one going down, and the other going up—you can make those observations yourself any day there, and you will find that three hours after high water, upon an ebb tide, there is slack water there, and at no time of the tide is there any considerable current over Erith Causeway. At 120 or 200 yards out from the end of the causeway, there is a down current, the eddy tide does not set up there, but the eddy tide is very marked indeed, and very curious there.

13,090. There must be something very exceptional there, because it is very remarkable that you should have a bight like this, with slack water, and it is for that reason I should like to see the currents laid down; there must be some abnormal conditions there at work?—There are, from its enlarged sectional area.

13,091. (*Mr. Abernethy.*) How is it with regard to the flood?—Upon a flood tide there is no eddy, but there is a very slack tide as far in as Erith Causeway.

13,092. (*Chairman.*) Sir John Coode raises a doubt how this can well be; but it rather strikes me as not an unreasonable supposition, because, the river bending round in this way, the flow of the water is against the north side of the river always, is it not?—The set of the tide there is for Coldharbour Point.

13,093. It flows against the north side?—Yes.

13,094. Then, when it gets below Erith, it flows against the south side?—That is not the explanation that I have in my mind. I would suggest that there is an excess of sectional area there. If you were to integrate the whole cross section, and add the whole tide running in one direction, and subtract the eddy tide going in the other direction, you would get at the true mean velocity of the stream.

(*Sir John Coode.*) I suggest that it is very remarkable; with this bight, and the current running through it, there should be this slack water here.

(*Mr. Michael.*) I am very sorry that Mr. Law was unable at the moment to be called, we are now interpolating Mr. Chatterton's evidence out of its proper order.

(*Chairman.*) I do not know if one may be permitted to assert one's own experience in a matter of this sort; it was always safe to keep upon what you call the convex side if you were rowing against the tide, was it not?

(*Witness.*) I do not know that.

13,095. As a rule it is at all events, because, if you have a concavity, the water would be more upon that side than it would be upon the other side?—That is all very well upon the Upper Thames, but I do not know that it will be a useful rule in the tideway.

(*Mr. Michael.*) I will pass this by for the present.

13,096. (*Chairman.*) Were not these causes in existence a long while ago—long before the sewage?—No, there was always an eddy tide at that place, but, on account of the dredging operations which have taken place recently, that effect has been more fully produced of late years.

13,097. (*Mr. Michael.*) You will see what the sectional area is at the present time, and how it has been increased, giving the reason for any deposit which has taken place. (*To the witness.*) Now we will go to the Erith Outfalls. You have examined all the existing outfalls, have you not?—Yes, I have. I have examined the sewer outfalls at Erith.

13,098. Will you state what nuisances you have observed there from the outfalls?—For any person working in the immediate neighbourhood of one of those outfalls there would certainly be a local nuisance. This (*producing a plan, see Appendix A M.*) is a plan of Erith, and immediately below Erith Pier there is a 15-inch sewer discharging on the river. That place where you see marked "Erith Gardens" upon that Ordnance map is called the South Eastern Railway wharf; I think it is Mr. Beadel's.

13,099. Does that mud remain uncovered by the tide?—Yes.

13,100. For how long?—I should think the end of the pipe would be exposed, from when the tide left it until the tide came up again, for three hours.

13,101. Have you noticed sewage coming out of that pipe?—I have.

13,102. What is the character of it?—I call it the "essence of sewage."

13,103. Do you mean it is so strong?—Yes, it is strong, and as if it had come from very badly constructed sewers.

13,104. (*Sir John Coode.*) Is there any reason why that should be more concentrated than the metropolitan sewage?—Yes, there are no good sewers in Erith, and it is old stagnant sewage.

13,105. (*Chairman.*) Is there any other criterion of the nuisance than the number of people who send it out?—Yes, I think the age of it, my Lord, the number of days between the time when it left the closet and got into the outfall; fresh sewage is not anything like so objectionable. But, however, I shall not say anything more about that, because there was a sample of it taken by the chemists, and they will explain to you what it was.

13,106. Can you give us what the population which drains into that sewer is?—That I will give, and

there is also a report of Mr. Edward Easton's which is put in.

(*Mr. Michael.*) It has not been put in, and I do not know when your Lordship would like attention to be drawn to various documents which have been agreed upon on both sides to be brought before the Commission. There are many important statements that we have agreed as to various points, and much has been cut out so as to make them as short as possible.

(*Chairman.*) We shall have summings up and speeches, and I suppose it would be done then.

(*Mr. Michael.*) That would be a break of continuity, and it would be desirable to have an opportunity of calling your attention to the most important passages as soon as possible.

(*Witness.*) What I say with regard to the outfalls is that a man working in the mud, and in the immediate vicinity of that outfall, in hot weather, must find it unpleasant; the mud will be tainted with the sewage. And if Sir John Coode will look upon the plan next to Erith Pier, and immediately below it, he will see a coal wharf, which was called the Erith Gardens; they try to bring barges alongside of that place, to unload them, and, in order to do so, they have excavated or dredged a channel in the mud there, and in order to keep that channel clean, they must flush it. You will see a place there called The Pier Hotel; immediately in front of that there is a tank, and that tank is filled every high tide, and discharged at low water, by which means it flushes out the portion in front of Mr. Beadel's wharf.

13,107. (*Sir John Coode.*) What is the "flood gate" one sees upon the plan, has that anything to do with it?—No, I think that is some land drainage. Now, that tank that I have referred to is not sufficient to keep the channel clear, but I have noticed that there are a certain number of men there, two or three men at work excavating, and always trying to keep the thing clear.

131,08. (*Mr. Lumley Smith.*) It would be convenient to have about the size of this tank?—I think it is about from 15 to 20 feet long.

131,09. But that does not give us the dimensions?—I have not measured it, it may be 25 feet long; you will see it at work any day down there.

13,110. (*Mr. Michael.*) Is there by the causeway another outlet of sewage?—Yes, there are a lot of small pipes coming in there. I have surveyed all those pipes and marked them on the plan myself; the most important of them is at the flour mill just above the causeway. I think I have called it upon the plan "Sewer C."

13,111. Does that run over the mud?—Yes, it runs over the mud that remains in a most disgusting state. When I went to examine it, I found a great quantity of sewage which had been deposited there the tide before, the tide is so slack there that it will not carry it away. The mud all along that place is locally fouled by the Erith outfalls, of which there are a good number.

13,112. (*Sir John Coode.*) Are there any more than you have marked upon the plan?—I do not think there are.

13,113. (*Mr. Abernethy.*) Are the dimensions marked upon the plan?—Yes, the dimensions are marked.

13,114. (*Mr. Michael.*) Is there any local accumulation of mud at the causeway of the Corinthian Yacht Club; in the first place, how is the causeway constructed?—The Corinthian Yacht Club Causeway is constructed on piles, and allows the water free passage for ebb and flood through the piles.

13,115. Does the mud accumulate?—No; there is a general accumulation all along the bight, but there is no local accumulation, that is to say, there is no heaping up at the causeway; the mud is no higher at the causeway than it is 100 yards above or 100 yards below.

13,116. What is the character of the other causeway?—The other causeway is a solid groyne running out.

13,117. Does that follow the usual course of groynes, heaping up the mud to the top of the causeway?—It does heap up the mud to the top of the causeway on the ebb side; on the other side there is no mud heaped up. I have no doubt that the way that causeway is constructed adds to the accumulation of mud at that place.

13,118. I think you have prepared a plan, have you not, upon which you have marked upon both sides of the river the factories which give out noxious smells?—I have. (*See Appendix BN.*) The most noxious factories that I know of on the Thames with regard to smell are the ones between Erith and Woolwich, upon the north side of the river. I have noticed lower down, upon the Essex side, there are some fish manure works, and then above that there are Messrs. Miller and Johnson's manure works, Wilson's chemical manure works, and above Rainham Creek there are the gas purification and chemical works, and the Rock Portland Cement Company.

13,119. (*Sir John Coode.*) That is hardly a noxious trade, is it?—It is not a smelling trade; it is a smoky trade. Then there is a candle factory above that, and then there is Crossfield's manure works, and then then there is the Barking guano works; then there is Lawes' chemical manure works, and then there is the Beckton gasworks; there are a great number above. I do not know that I need mention them all.

13,120. (*Mr. Michael.*) You have a list of them, have you not?—I have.

13,121. There are between 30 and 40, are there not?—There are 31 altogether.

13,122. (*Sir John Coode.*) Does that list include any other cement works?—No, but sometimes I have noticed a very nasty smell from those works. I do not think it is a real cement works.

13,123. (*Chairman.*) Are there discharges from those works into the river, or merely foul smells from them?—There are vapours.

13,124. (*Sir John Coode.*) I suppose any discharge from those chemical works is prohibited by the Metropolitan Board of Works?—The Metropolitan Board of Works have nothing to do with it, but the Conservancy would prohibit it.

13,125. So that, as far as they are concerned, it is a question of noxious smells?—Yes; it is for that purpose we have given them in the list.

13,126. (*Colonel Ewart.*) You did not notice any noxious discharge, except at Beckton?—No, I have noticed some discharge from one or two of the factories, but then it is only from a pipe.

13,127. (*Sir John Coode.*) If the discharge from those other factories is prohibited by the Corporation, or by the Conservancy, how is it the Beckton discharge is not prohibited?—I suppose that Beckton would say they merely discharge sewage.

13,128. (*Colonel Ewart.*) It is a question of how far the prohibition is enforced?—I do not think there is any prohibition enforced, or anybody who enforces it, at all events.

(*Mr. Lumley Smith.*) You will find some evidence upon the notes that what came from Beckton was pure water, and that there was no sewage at all in it; it does not follow that, though a discharge is seen, it is a noxious one.

Cross-examined by Mr. Lumley Smith.

13,129. Now, with regard to what you told us yesterday, in 1877 you were down, as I understand, upon work connected with the West Kent sewage scheme?—I was.

13,130. Not for the purpose of examining the river at all, but in the course of your duty, you had to be down upon the river?—No, I had double duty to perform. When I was appointed upon the West Kent works, the first thing was that I was ordered by the West Kent board to prepare soundings of the river,

*Mr. G. Chatterton.*

23 May 1883.

and an accurate survey of the bed of the river, in front of their works, because they anticipated that, in the event of any shoaling or unpleasantness taking place, they would be held responsible for it, and I was instructed to make the survey, which I did.

13,131. But that was not with a view of testing the quality of the water at all, but for the purpose of seeing the nature of the bed of the river in front of the West Kent works?—I believe also that samples of water were taken for the purpose of the West Kent works.

13,132. Where were the soundings taken that you spoke of yesterday at the West Kent outfall?—About 300 yards above Little Powder Creek.

13,133. As I understand, the result of your observations taken then is summarised in the general character you have given us of the banks—you do not produce any sections or any documents which were made at that time?—I do not.

13,134. But I think what you told us was that, as far as the banks were concerned, you did not find them covered with mud?—No; there is always mud upon the foreshore in Long Reach. When I knew the foreshore in Long Reach first, upon the south side it was mud between high water and low water, except in particular places. What I said was that I did not notice any change in the character of the mud between those dates—in Long Reach, from high to low water, it has always been mud.

13,135. Then it is the fact that between high and low water in Long Reach you do find mud?—Yes, and it always has been so.

13,136. Your observation dates from May 1877, I think?—Yes.

13,137. You tell us that you have not noticed any change in the character of the mud; between what dates are you speaking when you speak of there being no change?—The same dates, 1877 to 1882.

13,138. You still find mud upon the foreshore, do you not, between high and low-water mark?—Yes.

13,139. It is a straight long channel, the name Long Reach rather points to that?—Yes, it is a straight long channel, but the bed is uneven.

13,140. Is there a considerable current down the bed?—Upon the north side there is.

13,141. Your observation is based upon what you saw upon the bank, I understand?—Yes, walking about the bank.

13,142. We have had some evidence about anchors which were taken from the bed of the Reach, and so on. You have had nothing come under your observation, have you, which would show the condition of the bed of the river?—I have.

13,143. What have you?—When I sounded I took the samples. Every time I take a sample the pole is pulled up afterwards, and I look at it to see what is on the bottom. The sounding pole is of wood, with an iron shoe upon the bottom of it. I got that hollowed out and grease put in it to pick up whatever was upon it. Upon the gravel you can hear it, and upon the shingle and the sand you can hear it, and you know it at once; but in the mud you take it up. The man who is sounding takes a look at it, and very likely smells it. I ask him if it smells, and he says whether it does or does not.

13,144. But what is the result of this?—There has been always mud in parts of Long Reach, but there has not been mud all along the bed of the river.

13,145. I cannot understand why you should have required to have it smelt in 1877. I can understand why you should have it smelt now?—I have always examined the river in that point of view to see what effect the sewage would have upon it. As we, the West Kent people, were discharging sewage into the Thames there, and I being placed in charge there, it was natural I should acquaint myself with the character of the river before the sewage was discharged into it, so as to be able to compare it with what it was after the sewage had been discharged into it.

13,146. You were providing yourself with knowledge and materials in case an inquiry arose as to what was the state of the river and of the mud before and after?—Yes, and for another reason.

13,147. But that is sufficient; have you kept no memoranda at all with regard to the character of the mud?—Not as to the smell, but it is to be characterised as a light mud and a dark mud.

13,148. The year 1877 was a wet year, was it not?—I do not remember.

13,149. I am told that one of the biggest floods that ever occurred in the Thames happened in 1877; are you able to tell me whether it was or was not a wet year?—I am not. I have not the tables with me.

13,150. Can you give me the times when you made your observations in 1877?—Yes, May 4th, May 8th, May 9th, May 10th and 11th, and the whole of June, I was upon the bank there, and a great deal upon the river; also the whole of July, and the whole of the rest of that year.

13,151. Where do you get your dates which you took; from your reports, or from memoranda made at the time?—They were taken from my level books principally.

13,152. I presume, from your not putting them before us, that there is nothing in them specially with regard to the character of the mud?—No. Then I should say that I refer to the tables of the temperature of the Thames upon those days. I did not take the temperature myself, but I look to the common source of information, the Greenwich records. I have them all copied out, for ever since they were taken, from the year 1844 to the year 1879, when they were given up, and if his Lordship cares about it, I will present that to the Commission.

13,153. That is copied from the record at Greenwich of the temperatures of the Thames?—Yes.

13,154. Taken where, at Greenwich?—Yes.

13,155. But you have no memoranda at all with regard to any smells of mud at that time?—No; there never was a smell.

13,156. But have you any memoranda made at the time?—No, I have not.

13,157. Where do you get those dates, May 4th, 8th, 9th, 10th, and 11th?—They are taken from my level and sounding books.

(*Chairman.*) It is remarkable that you should have thought it necessary in the interests of your employers that you should make an inquiry into the condition of the water, and should have made no notes or memoranda of your observations.

13,158. (*Mr. Lumley Smith.*) Do your sounding books show anything more than the depth of water and the existence of mud?—They show where the mud is.

13,159. Not the character of the mud?—No, not the character of the mud, but where the mud is as compared with gravel and sand; I must rely upon my memory for the character of the mud.

13,160. (*Sir John Coode.*) Are the level books forthcoming?—The level books are not here, but they can be produced; but there is nothing in them except a mass of figures which relates to a matter which is not now before the Commission.

13,161. (*Mr. Lumley Smith.*) After 1877 your occupation there ceased, did it not; what had you to do then?—I had nothing then to do with the West Kent Drainage after 1877. I was then in partnership with Mr. Henry Law.

13,162. When were you next taken down to the river?—I was engaged to survey the banks of the river in 1878.

13,163. Was that with a view to the Mud Inquiry?—It was with a view to a Report that was issued afterwards.

13,164. For the Board of Works?—For the Board of Works.

13,165. It was not in 1878 that you at all went upon what I may call your smelling excursion?—No, that was last year.

13,166. Have you any memoranda in 1878 with regard to the character either of the water or of the mud?—No, I have none: that was when the investigation

was made for the Mud Inquiry; there are ample records of the condition of the water during that period which will be put in by our chemists when they come.

13,167. As far as you personally are concerned, you give us no information with regard to your visits in 1878, except as to your going down in a steamer in February? — I walked down the river banks in February to Yantlet, and visited all the saltings.

13,168. But yesterday your evidence was confined to having gone down in steamer after the loss of the "Princess Alice"?—I was out upon the river 37 days in that year altogether, and the 23rd November was one of them.

13,169. How do you get the 37 days?—I have taken that from my level books. I have no regular diary. I was down the river 37 days as I make it, it may be more or it may be less, but I took it as 37 days from my level book; many of those times were unconnected with this inquiry.

13,170. Were you taking levels in 1878? — Yes, almost the whole year; I was engaged for the Metropolitan Board of Works in connexion with the purchase of the toll bridges.

13,171. I do not remember any bridge at Purfleet? —No; when I say 37 days, I mean on the river. I do not say 37 days at Purfleet.

13,172. But we are dealing now with below London; I do not see how any days that you spent above London Bridge, say at Putney or Hammersmith, can affect this question?—No, that is true.

13,173. But it appeared yesterday as though all the days you mentioned you had been on the lower river? —That was not what I intended to convey.

13,174. (*Prof. Williamson.*) When you speak of 37 days, does that mean that on 37 days you were there for some indefinite period, or does it mean 37 times 24 hours?—No, it would mean a day's work upon the river of 6 or 7 hours each; the greater part of these 37 days I was not below the outfalls at all, but up the river between Waterloo and Hammersmith Bridges, and up the river generally.

13,175. (*Mr. Lumley Smith.*) On how many days in 1878 were you down at the outfalls, or below them? —I do not remember, but I should say perhaps 10 out of the 37.

13,176. What business were you on down below?— I made some current observations of the set of the tide for the Mud Inquiry, which was heard. I was engaged making float observations.

13,177. The mud case came on a little later?—Yes, but still we were preparing for it, and there was a Report published in that year for which I did most of the out-door work.

13,178. Could you give me the date of the Report? —It is April 1878.

13,179. That is the Report made in 1878; now, were the occasions upon which you were down the river near the outfalls in the spring of 1878?—There were a good number of them.

13,180. If they were for the purpose of preparing this Report, they must have been before April; now are we to take it that your visits down the river in 1878 were all before April 1878?—Not all of them.

13,181. Were the bulk of them?—I could not remember that at the present moment.

13,182. I suppose we may take it up to the end of April, that is not the season of the year at which the river as a rule is offensive?—It is not.

13,183. Therefore, as far as your visits are concerned before April, they would not affect the matter? —I was upon the river 10 days in March, four days in April, and six days in May and June.

13,184. All below the outfall or partly in connexion with the toll bridges?—It was partly in connexion with the toll bridges.

13,185. That is no use to me. What I want to know is upon how many days in April you were below the outfalls?—I do not remember.

13,186. Were you down below the outfalls any days between April and when you went down in a steamer in November?—I cannot tell you.

13,187. Now, with regard to the steamer, people, as I understand you, have been alleged to be poisoned when the "Princess Alice" went down?—Yes.

13,188. And then, in consequence of that, the Board sent some members of the Board down in a steamer, and you accompanied them?—I think all the members of the Metropolitan Board of Works went down to see the river themselves, and invited reporters down with them, and I myself went down.

13,189. I rather gathered from you yesterday that the Board of Works satisfied themselves that there was nothing in the condition of the water to poison the people who were immersed from the "Princess Alice"?—I do not think the Board stated that, but I think they instructed their chemist, Mr. Keates, to prepare a report upon the subject.

13,190. Your visit was in November 1878, and the disaster to the "Princess Alice" was upon the 3rd of September?—It was.

13,191. So that the condition of the water in November would not be any criterion of the condition of the water in September?—It would not.

13,192. Upon that occasion, as you stated, you collected the sample from Beckton?—I did.

13,193. What is the size of the sewer there?—It is an egg-shaped sewer, about 2 feet 6 inches high. I think it is a well known sewer, it is the most stinking place I have ever been in in my life, and the foreshore is in the most disgusting condition I have ever seen anything.

13,194. What we want to know is, what kind of smell is it?—A gasey kind of smell, in fact, a heterogeneous collection of smells.

13,195. (*Sir John Coode.*) I should like to know what was the quantity of fresh water which came over Teddington Weir between the accident to the "Princess Alice" and this inspection in November, because the condition of the river would depend in a very great degree upon there being much or little water in the river?—But I think the chemist went down and took samples of water immediately after the disaster.

13,196. What I should like to know is, what was the condition of the river water immediately after the disaster to the "Princess Alice," and between that and the time of Mr. Chatterton's inspection upon the 23rd of November?

(*Mr. Michael.*) That you shall have.

(*Sir John Coode.*) We can get it from the Thames Conservancy, we will go to the fountain head.

13,197. (*Mr. Lumley Smith.*) I am afraid Mr. Taylor's tables are not quite to be relied upon, and that is the reason we gauged the river later on, and that gave it us more accurately; but our records do not begin quite early enough. (*To the witness.*) Now, with regard to this sample which you took upon the 23rd of November 1878, what did you do with that; you gave it to Mr. Keates, did you not?—I handed it round and gave them a smell, and then I passed it on to Mr. Keates.

13,198. (*Chairman.*) That was the sample taken from the outfall at Beckton?—Yes.

13,199. (*Mr. Lumley Smith.*) Which you said smelt gasey?—Yes.

13,200. Now let us come on, if you please, to the occasion when you went down seriously for the purpose of seeing how far you could detect smells coming from the outfalls; one of those dates was in 1879, was it not, or can you give me the date of the first occasion?—The 22nd May 1882.

13,201. Was that the only occasion upon which you put in your float and followed it down the river, testing the smells as you went, or did you do it upon more than one occasion?—I have mentioned one other occasion upon which I did it.

13,202. Can you give me the date of that?—I am not quite sure that I did put in the float any other day to follow it.

13,203. Are we to take it that there was only one

*Mr. G. Chatterton.*

23 May 1883.

occasion upon which you conducted this experiment for the purpose of testing the smells?—I followed the sewage down upon a great number of occasions.

13,204. But you have given us with a good deal of precision what happened upon the 22nd May 1882, and then my learned friend Mr. Bidder put it to you that you had taken other observations afterwards. Are we to take it that that is the one you rely upon, viz., the 22nd May 1882?—I think that was the only day upon which I had a float out, but there was another day upon which I lay in the boat and smelt the water.

13,205. What was the day that you lay and smelt the water?—Upon July 14th 1882; I made some careful observations upon that day: I went down the river from Woolwich to Erith in an open boat, and at Jenningtree Point I noticed that there was a good deal of that bubbling which you see in the Thames; I smelt the water very carefully that day.

13,206. That was the 14th July 1882; now, are the two occasions upon which you made notes of what you smelt for the purpose of this inquiry, as we understand, May 22nd and July the 14th?—And July 27th also. I was on the river a great deal, as I told you, in June, July, and September, but, having done it so fully upon that day, I did not do it again.

13,207. Then it comes back to this, that, as far as precise observations are concerned, what you rely upon are the observations you made on the 22nd May 1882?—I cannot say that I agree with you there; I was upon the river the whole year, and if there were any bad smells I did not smell them; I cannot separate one particular day out, I will take them altogether.

13,208. Then the only occasion upon which you made any careful observations upon the smell of the water and of the shore was upon the 22nd of May 1882?—It was not; those are my notes as I gave them to you; they are practically my proof.

13,209. What I want to know is this: upon May 22nd 1882 you went and made your notes, smelling carefully as you went along, until you lost the smell?—I did.

13,210. Have you the notes now?—No.

13,211. Where are those notes?—I made them a year ago; I do not know where they are now; I wrote my proof, as far as that is concerned, a year ago, and I do not know where those notes are now.

13,212. But did it not occur to you, as being an intended witness here, that it would have been satisfactory to have had those notes?—I do not think so.

13,213. Have you the notes of July?—I do not think I have any notes; I took notes from time to time, and I jotted them down, and they are in my proof.

13,214. When was the proof written, can you tell me that?—A long time ago. My note as regards the observations of May 22nd was written a few days afterwards.

13,215. Have you got it?—I do not know; I dare say it has gone to the Board of Works.

13,216. Have you no original observations now?—No.

13,217. Nothing but your proof which is now before you?—No.

13,218. (*Prof. Williamson.*) I understood you to say just now that in one part of the river you noticed a bubbling of the water; I should be glad to know whether you had occasion to examine any of the mud which was at the bottom at that place where the bubbling was perceived; because, of course, it is known that bubbles are evolved chiefly where organic matter is undergoing active decomposition?—I have noticed a great deal of bubbling in the Thames, and anybody can notice it who goes down there on a summer's evening; you will notice it in Jenningtree Point, you will notice it in Erith Bight; as far as Long Reach you will notice bubbling; and what I wanted to satisfy myself was, was there any nuisance from those bubbles. I supposed they were in some sort of way the result of putrefaction, and I got my nose as close to the surface of the water as I could, but I could not perceive any odour from them. When I have been sounding, I have noticed them very much, and I have also noticed bubbles coming from a sandy bottom. I have been told it is absurd, that bubbles cannot come from a sandy bottom; but I disagree with that.

13,219. Did you take occasion to examine specially the mud underneath that part of the surface in which the bubbles appeared?—Yes, I did.

13,220. With what result?—I did not notice any difference from the ordinary mud upon the banks.

13,221. (*Dr. Stevenson.*) You did not collect any of those bubbles for the chemist, did you?—No, I did not, I tried to do it, but I could not do it.

13,222. (*Chairman.*) You stated that you saw them more particularly in Erith Bight, where the slack water goes?—Yes.

13,223. Where you say no sewage goes?—I did.

13,224. It might be Erith sewage, by the way, might it not?—I do not say that. As a matter of fact, I do not think the bubbles are any harm to anybody.

13,225. It depends upon what they come from?—I have examined them, and smelt them; there is nothing in them; anybody can go and see the bubbles, it is a matter of common observation.

13,226. (*Mr. Lumley Smith.*) You think nobody ought to find fault with them?—I never heard anybody find fault with them; I never heard anybody say they smelt them, and I do not believe they ever did.

13,227. You think bubbles are no nuisance, and that a nuisance does not arise from them?—I do.

13,228. Do you then entirely disbelieve the statement that patches rise from the bottom and give off odours?—I do not believe it; if you will point to the passage which states that, I will tell you what I think of it.

13,229. Now upon the 27th of July what was the condition of things when you lay down and smelt the water; whereabouts was that?—From below Jenningtree Point to above Crossness.

13,230. How came you to be out there; what were you doing upon that occasion?—Upon that occasion I went down with one of the chemists to take samples.

13,231. But you were coming up stream upon that occasion, how came you to be coming up stream?—I was coming back in the tug.

13,232. In what state of the tide was that?—That was upon the ebb.

13,233. Now, with regard to May 1882, in which month you took your careful examination, I just want to see with a little more detail what you did; you went, as I understand, in a boat to the opening of the outfall?—I did.

13,234. And waited for the outfall being opened at high water?—I did.

13,235. How far off were you from the outfall then?—I was just under the apron.

13,236. Then of course the sewage would come immediately all round you?—I shall never forget it.

13,237. As you tell us, it is a smell that is like no other smell?—It is a smell that is like no other smell; it is very disgusting.

13,238. You did not stay there longer than you could help?—I stayed there to put in the float.

13,239. And then you followed the float?—I did.

13,240. And that floated away?—Yes.

13,241. Then how soon after the outpouring of the sewage commenced did you put your float in?—Immediately.

13,242. Did you allow it to take its own course?—Yes; I did.

13,243. And followed it down the river?—I simply wanted to follow some portion of the sewage as it were.

13,244. And, in fact, you did follow the float down the river?—Yes; I did.

13,245. Keeping with it, I suppose?—Yes.

13,246. This was at the time of high water?—Yes.

13,247. And at the time when the bulk of sea,

water, the water which had come up from the sea would be at the highest opposite the outfall?—Yes.

13,248. And when whatever was put into the water would go into the largest quantity of water?—Yes.

13,249. Does it not occur to you that this was rather, for the purposes of your case, a favourable opportunity to test the sewage coming out of the outfall, because you would be following the very first spoonful of sewage that went out from the outfall, which in its turn would be going into the largest possible quantity of unpolluted water. In the first place, are my facts correct, that you are taking the very first outfall of sewage into the largest bulk of unpolluted water?—I do not think they are quite correct.

13,250. Why not?—Because I was there some time after high water.

13,251. But it was immediately that they opened the outfall?—The high water that day was one minute past five at London Bridge, and high water down there would be about 25 minutes to five. A float being put in there at Barking (as everybody knows, at high water it is slack water), it takes a long time at first for the float to move a little bit; it was a quarter to six when that float was opposite the reservoir. I only wish the float had gone away sooner because it kept me out in that place longer than I wished. I was there at five o'clock, and it was a quarter to six before it moved away, so that I was there three-quarters of an hour before it moved away.

13,252. But do you say the sewage was not moving away?—My float was not moving, but that is no reason why the sewage should not be moving; the sewage comes out and spreads itself out in the river like a fan, a very distinct line of demarcation being established between the sewage and the rest of the water. If my float had gone out and got into the outside line of the sewage, and got the start of the sewage, I would have been all right,—the fact was, the sewage was beginning to be discharged at five o'clock, and I was there for three-quarters of an hour.

13,253. Now you are giving us particular minutes, and we should like to have your original memoranda; were they sent in to the Board?—I do not know whether they were or not.

13,254. Does not it occur to you that it would make a great difference, as regards the mixing, whether you started with the sewage at high water, or whether you began when the sewage had half flowed out?—No, I think I was there at the most unfavourable time for the sewage, because in the first half hour of the tide the first four feet of the sewage goes off; so I worked in an abnormally large volume of the sewage; after that it falls away and discharges as the tide falls.

13,255. (*Chairman.*) Does more come out at high water than afterwards?—Yes, it must do so.

13,256. At the first discharge?—Yes, I have never gauged it, but I should think it must be.

13,257. (*Mr. Lumley Smith.*) The fact remains the same, that you took this observation going down with the float, which was put in when the outfall first commenced, and at high water?—Yes.

13,258. So that the quantity of water which comes up from below would be the highest possible, and you would get away from the outfall with the very first quantity of sewage which came out?—I told you I got away after three-quarters of an hour's discharge.

13,259. (*Mr. Abernethy.*) The high water would be the period of minimum head of the reservoir, would it not?—No. I think the level of the weirs of the reservoir is 16·50 above Ordnance datum; that is 4 feet of high water.

13,260. But the period of high water was not the period of the minimum head in the reservoir; the head would increase as the tide fell, would it not?—I should say that at high water it would fall more rapidly.

13,261. (*Chairman.*) What is the outlet, is it through some bore or culvert?—Through a culvert.

13,262. Not over a lap as it were?—No; there are penstocks in the reservoir; they are all lifted at nigh water, and the sewage rushes out at first, and when it reaches a sufficient level, then it falls gradually with the tide, as Sir Joseph Bazalgette told you yesterday, four hours after high water, and it ought to be three. It has got a greater head to start with, and it runs that off, and then discharges more slowly.

13,263. (*Mr. Lumley Smith.*) However can you say there is nothing in my suggestion; I say there is the maximum of water to dilute, and that you would go off with the van of the outfall?—I meant to take it in every way that would be against the outfalls, and I think I succeeded.

13,264. However you may have taken it against the outfall, the question is whether you succeeded?—I did my best to make it fair, and I think I succeeded.

13,265. Have you made any note of the direction of the wind?—There was hardly a puff of wind; the wind was south, south-west, and as the afternoon came on there was hardly any wind; it was a lovely afternoon.

13,266. Was the water quiet?—Yes, it was as smooth as glass.

13,267. You told us that after you had lost any sense of smell from the water, that if you shook it in tubes you detected a smell then?—Yes, you are quite right; when the sewage comes out first of course you can smell it.

13,268. I think I am correctly reproducing what you said yesterday; you got to a certain point where you ceased to smell it, when you sat in the boat?—Yes.

13,269. But that when you shook it up in a tube you could smell it?—Yes.

13,270. Now I will ask you this: I suppose the passage of a screw steamer would have the same effect as shaking the sewage up in the tube, would it not?—No, because when the screw of a steamer shakes it up the smell has some space to disperse into, but when you shake the stuff up in a test tube, and put your thumb upon the top, and then smell it, you get the first whiff of it.

13,271. Perhaps your sense of smell from having been so long in the smell was not so acute as if you had come from the sea to Jenningtree Point, when you would have smelt it?—I do not think it was at all impaired.

13,272. (*Sir John Coode.*) You told us yesterday that you thought the effect of a screw steamer was very much like shaking a test tube?—I certainly put the test tube first and the steamer afterwards; still it is a capital way to smell it, to sit in a boat behind the screw of a steamer.

13,273. (*Mr. Lumley Smith.*) You told us that the last time you could smell it was below Jenningtree Point?—It was some distance below Jenningtree Point.

13,274. Was that in the water or when it was shaken in a tube?—It was when it was shaken in the test tube; it was some little distance below Jenningtree Point.

13,275. You said that at Bow Creek you saw a large quantity of sewage coming down; when was that?—The 3rd of July at 9 o'clock.

13,276. Have you any memoranda of that?—I took two samples and sent them to the chemist.

13,277. There is in Bow Creek a storm overflow is there not, belonging to the Metropolitan Board of Works?—Yes, somewhere up Bow Creek, I believe, there is.

13,278. Did you go up Bow Creek to see where the sewage came from?—No; but I am pretty sure that it came from the West Ham sewer.

13,279. I am rather trying to divide your evidence into what you know of your actual knowledge, and what you derive from conclusions that you draw. Did this make any considerable stream out into the river?—It was getting on towards low water; it was the ordinary flow of Bow Creek.

13,280. Did this make any considerable smell in the

*Mr. G. Chatterton.*

23 May 1883.

river?—It was a cold morning, and you could not smell it.

13,281. But did it make any considerable appearance in the river?—I was going down taking samples, and I noticed the sewage coming down Bow Creek, and I stopped the boat and went up the creek as far as the Thames Ironworks, about 200 yards up the creek. I noticed the sewage or dirty water coming down, and I took samples of it, and sent them to the chemist. I think there were about 3 feet 6 inches of water there.

13,282. (*Sir John Coode.*) Do you mean in the creek or that the sample was taken 3 feet 6 inches under the surface?—No, in the creek. I think the sample was taken 2 feet below the surface.

13,283. (*Mr. Lumley Smith.*) Did you meet any stream coming out into the Thames; could you follow it for any particular distance?—I did not.

13,284. Now with regard to pumping from barges, you told us that upon the 3rd of July, opposite Blackfriars Bridge, you saw a barge pumping out something; do you attribute importance to that?—I do not, except that in the Thames there is nobody to look after the vessels; they put what they like into the river, and I do not think it is right that people should go opposite the embankment and pump what they like into the river.

13,285. That is what we may call *alia enormia*, that other people foul the river besides the Metropolitan Board of Works?—Yes.

13,286. You went on board a Dutch boat, you say, in August?—I did.

13,287. Now, you are aware that 1882 was an exceedingly wet year, that the river was exceedingly sweet except in one particularly part of the year 1882?—I do not remember that.

(*Chairman.*) We may take judicial notice, I think, that last year was a wet year.

13,288. (*Mr. Lumley Smith.*) You gave us some information to-day about the floats; you say you made some float experiments, and none of the floats went into Erith Bight?—No, none of the special ones. On one occasion following a float it did traverse Erith Bight, but that was one of the float observations made later in the year.

13,289. When was that?—My men were doing it; that was the time when the corporation float experiments were going on.

13,290. You were watching them?—I was watching them, and they were watching us.

13,291. What were the float observations about which you are giving evidence upon to-day; when were they taken?—They were taken during the summer.

13,292. For the purpose of this inquiry to satisfy your own mind?—Yes.

13,293. Were they for the purpose of this inquiry?—Yes.

13,294. Were they made for the Board of Works?—Yes.

13,295. I suppose you made observations of them?—I did.

13,296. Where are they?—I do not know.

13,297. But this is an inquiry in which one likes to be as precise as possible; where are the memoranda that you made of those observations?—I have them all in my mind. I was watching Mr. Birch's observation. I know the set of the tides perfectly well, and I did not write them all out.

13,298. But you made certain memoranda for the purpose of the Board of Works; where are they?—One of the float observations would be watching the sewage flow on the 22nd of May. I say I watched the set of the current in those reaches most carefully and attentively, and these which I have given are the result of my observations, watching them: and I give them to the Commission for what they are worth.

13,299. (*Chairman.*) These are your observations at the time, and you made notes at the time, I presume?—Yes, I did.

13,300. But you have not got them with you?—I have not preserved them.

13,301. Then I should advise you another time to preserve them, because you might at any time be called upon to justify the observations you made in your report?—I am sorry I did not keep them.

13,302. (*Mr. Lumley Smith.*) Now what did you do with them?—I do not know.

13,303. Now, with regard to the float experiments you have been telling us about to-day, they were float experiments for the purpose of seeing which way the sewage went?—I was down the river when the corporation were making their float experiments.

13,304. But that was not in the month of May 1882?—No, that was in November or October.

13,305. I want to know when you first reduced into shape your observations upon the current floats?—I do not believe I ever reduced them. I made them, and I have them all in my mind.

13,306. When did you first reduce them to shape?—I did not so reduce them; they had never been put into shape until they appeared in my proof.

13,307. When was that?—Some time before Christmas.

13,308. And you have no memoranda which show the result of your observations except what you have put in your proof?—No, I have not, but I have practical experience in it.

13,309. You can give us no memoranda?—No, I cannot. If you doubt my observations, the only way to do it is to go and see it yourself.

(*Chairman.*) Do not you see what is the effect of that answer? It amounts to this, that all I have said is of no use.

Cross-examined by Mr. Beaumont Morice.

13,310. You have told us that there is no difference in the mud along Erith Bight; is that so?—There is a slight difference in the colour I think, but there is no great difference in the mud near Erith Causeway.

(*Sir John Coode.*) Do you mean as between one part of the bight and another, or as within the period between 1877 and 1882?

(*Mr. Beaumont Morice.*) As between one time and another?

(*Witness.*) I thought the question referred to between one part of the bight and another.

13,311. (*Mr. Beaumont Morice.*) You have no knowledge of Erith before 1877, have you?—I have this much knowledge: I made a boring of the mud bank in 1878 at Erith 10 feet deep. I drove a tube into the river 10 feet deep.

13,312. But before 1877 had you any knowledge of the state of the mud in Erith Bight?—I had not.

13,313. During the period from 1877 to 1882 how often had you been yearly upon the river at that spot?—I was there more last year than at any other time.

13,314. But that is not an answer to the question. How often have you been upon the river at that spot?—I cannot divide it up.

13,315. Let me take it by years, beginning with the year 1877?—In 1877 I was not in Erith Reach. I have not spoken of the Erith mud in 1877. I have spoken of the Long Reach mud, not of the Erith mud.

13,316. But you stated, in answer to my learned friend Mr. Bidder, that the state of the mud in Erith Bight was of the same description as the mud in other places?—No; I stated the condition of the mud in Long Reach.

13,317. Then you have no experience in 1877 of the mud of Erith Reach?—No; I took a boring of the mud in 1878 in Erith Reach.

13,318. Then in 1878 do you remember how often you were there?—I do not remember how often I was there.

13,319. Were you there at all?—Yes; I have told you I took a boring there.

13,320. Were you there more than once?—I was there a dozen times between Purfleet and the outfall.

13,321. Have you any notes of how often you were there in 1878?—No, I have not.

13,322. In 1879 how often were you there?—I was very little in Erith in 1879. I was principally in Long Reach.

13,323. And in 1880?—In 1880 I was not very much there either.

13,324. And in 1881?—In 1881 I was not very much in Erith. I have not mentioned Erith in any one of those years.

13,325. Were you there at all?—Yes, I was.

13,326. In 1882, last year, were you there?—In 1882 I was. I was there last year a great deal.

(*Chairman to Mr. Michael.*) I do not know whether you will bring forward some of the inhabitants to say that they do not smell this smell that has been so much talked of.

(*Mr. Michael.*) I cannot say as to that, but we shall have some medical evidence.

(*Chairman.*) Mr. Morice is asking these questions with a view to see what knowledge Mr. Chatterton has generally of the subject. If a man who lives upon the bank of the river were examined, and could say, "I live there habitually and do not not smell this smell," that would be a different thing.

(*Mr. Beaumont Morice.*) I do not think my learned friend can do that.

(*Chairman.*) I assume Mr. Michael, judging from his look and gesture, will say that all Erith is against him; in that case it does become important to examine into the knowledge of a gentleman who is not locally prejudiced.

13,327. (*Mr. Beaumont Morice to the witness.*) You say you were there a good deal last year; how often were you there?—I was there in May. I was there in June. I was there in July. I was there in August. I was there in September. I was there in October, and I was there in November. I was down the river in all 59 days between May and November; and on about 45 out of those days I was past Erith. I sounded Erith Reach and Erith Rands last autumn. I took a great number of sections there, which will be put in; that alone took me a great number of days, and I lived down at Erith when I was doing them.

13,328. How long did you live at Erith?—Three or four days at a time.

13,329. (*Sir John Coode.*) Were any of these sections taken at Erith in the immediate locality?—Yes; Mr. Law will put them all in.

13,330. (*Mr. Beaumont Morice.*) With respect to your visit in November after the Princess Alice accident, you know as a fact, do you not, that the river is generally in a better state in November than in the preceding month?—It depends upon whether there is any land water that comes down.

13,331. But the river is generally in a better state in November?—Yes, certainly, the temperature is lower.

13,332. (*Sir John Coode.*) And there is a greater quantity of water coming down?—Yes, certainly, as a rule.

13,333. (*Mr. Beaumont Morice.*) Have you ever been in the neighbourhood of the river at Erith in August and September?—I was down there almost all August and September last year; my soundings were almost all done in August and September.

13,334. At what part?—From half a mile above the Corinthian Yacht Club to half a mile below Messrs. Easton and Anderson's works. I went there intending to make a survey of the river from Jenningtree Point to Dartford Creek, but I was not able to do so; I had not time.

13,335. (*Sir John Coode.*) Are not Messrs. Easton and Anderson's works somewhere to the eastern part of Erith?—Yes.

13,336. Almost immediately to the eastern part of Erith?—Yes, I took something like 44 cross sections of the river.

13,337. (*Mr. Beaumont Morice.*) Have you taken any soundings in Erith Bight proper?—Yes, I tell you I took about 44 cross sections of the river between those two places which I named.

13,338. But have you made any between the pier and the Corinthian Club-house?—Yes.

13,339. How many have you made?—Sixteen.

13,340. How many days were you taking soundings between those points?—I really could not tell you unless I referred to my level book. My sections were about 400 feet apart. I do not know what the distances are exactly.

13,341. Could you produce the level books, because I should like to know how many days you were taking soundings between Erith pier and the Corinthian Yacht Club-house?—I will give you that information, I have no doubt.

13,342. (*Mr. Balfour Browne.*) That is to say you will produce the level books?—I will produce the books of the soundings between Erith Pier and the Corinthian Yacht Club-house.

13,343. (*Mr. Beaumont Morice.*) You will give us the book in which you made those entries?—Yes, I will.

13,344. Do you know the character of the mud between those two points?—Yes, I do.

13,345. Is there any difference, judging without going into it chemically, between the ordinary mud in other parts of the river and that mud?—I do not think so.

13,346. Have you ever been on Erith Pier at ebb tide?—I have.

13,347. And seen the deposit?—I have.

13,348. Have you been down the causeway?—I have.

13,349. Do you mean to say the mud there was the same as in other parts of the river?—I do not think there is any difference. I am only speaking as a casual observer, but I think you may take it from me, that you will have chemical and other evidence upon that point which is more valuable than mine.

13,350. I ask you, if between those two points, Erith Pier and the Corinthian Yacht Club-house, there is any difference between the ordinary character of the mud and that in other parts of the river?—There is a slight difference which I think can be detected by the eye, between the mud at the Corinthian Yacht Club-house and the mud at Erith Causeway—the mud at the Corinthian Yacht Club-house is more compact and of a slightly darker colour than the mud at Erith Causeway—I take it that the reason of it is, that there is a stronger current at the Corinthian Yacht Club-house than there is at the Erith Causeway, and that it has washed away the finer particles of the mud, more than it has at the Erith Causeway. There is a difference in the texture of the mud if I may call it so.

13,351. You know upon the causeway there is a large deposit of mud?—Yes, I do; caused by the bad construction of the causeway, and generally acknowledged by the Erith people to be so.

13,352. Do you know that the deposit is upon both sides of the causeway?—I know that upon the lower side of it, it is sometimes from 2 feet to 2 feet 6 below it—it acts the part of a groyne while on the other side of it, it is upon the level of the causeway.

13,353. Do you know that upon the lower side there is a deposit of from 6 to 8 feet of mud?—I should not be surprised if there were. I made a boring of 10 feet.

13,354. You sounded and therefore stirred it up?—I have driven a rod into it.

13,355. Do you mean to say after that, that it is what you call the ordinary kind of mud?—Yes, ordinary river mud; there is no difference between that and ordinary river mud.

13,356. Is it slimy?—No, I do not think it is.

13,357. You know Mr. Beadle who has been

*Mr. G. Chatterton.*

23 May 1883.

examined here, do you not?—I know there is a Mr. Beadle who lives there.

13,358. But you know he gave evidence here, and you heard him examined here?—I was not here the first day, and I do not think I heard him examined.

13,359. Do you know that Mr. Beadle referred to this mud as a slimy greasy mud?—I do not know that. I do not think there is any difference in it from ordinary river mud.

13,360. Have you ever found any smell from it?—I have, just where the Erith outfall comes out. I have noticed the Erith outfall, but I have not smelt that mud.

13,361. When you were sounding this mud by the causeway, did you find any smell when you brought up your rod?—No, nothing more than ordinary river mud, all mud smells a little.

(*Chairman.*) I do not understand Mr. Chatterton to be a witness called by the Board for the purpose of showing the condition of this mud.

(*Mr. B. Morice.*) He has stated that there is nothing of a sewage or bad smell in the mud.

(*Chairman.*) He rather himself declined being that witness—he says "If you ask me, I will tell you what "I think about it, but there are other witnesses more "competent to speak about that than I am." Is that so?

(*Witness.*) Yes, I am not a chemist nor a microscopist and there are such who will be called before you.

13,362. (*Mr. B. Morice.*) Then I will go to another point; you have told us about the different factories?—Yes.

13,363. Can you tell the different smells of those factories?—I cannot distinguish every one of them, but you can put them into groups; they are very marked. I can tell, for instance, the smell of the fish manure from the others.

13,364. Speaking generally, you can tell the different smells?—Yes.

13,365. How often have you had an opportunity, by being down there, of judging between the different smells?—Every day that I was down there, when the wind was favourable, I smelt the factories from one side or the other.

13,366. During the period you have told us?—Yes.

13,367. You smelt them when you were upon the river?—Yes, and upon the land.

13,368. Have you ever smelt the sewage smell at the same time?—No.

13,369. If there had been any sewage smell you would probably have been able to distinguish it, would you not?—Upon my word, I cannot tell you that; I think I could tell the smell of sewage just below the outfall from the smell of the factories; certainly I could. Sometimes they are a little alike, but with practice your nose can detect the difference.

13,370. Therefore if persons resident in the locality say that they can distinguish between the two you would agree with them?—Yes, if they have had much experience.

13,371. You told us that the sewage smell was a local smell, and was disgusting?—Yes, but you must remember that when I told you that it was disgusting it was when I was in a boat in the middle of the sewage of all descriptions, but when you are out on the river 200 yards from the outfall there is a very different smell from the smell at the outfall.

13,372. You have never smelt that smell, though you have smelt the factories?—I have smelt the factories a great number of times.

13,373. Now with regard to the sewers of Erith; you have heard the evidence given by the surveyor to the Local Board?—I have.

13,374. Do you know how many houses there are in Erith?—I think I did, but I forget now.

13,375. I will remind you that there are 1,883 rateable houses; do you know how many of those are drained into the Thames through these sewers?—I know it was given in evidence; I do not remember the figure.

13,376. It is 507?—I have read Mr. Easton's Report upon the sewerage of Erith.

13,377. Will you kindly bear in mind that I am upon the evidence of the surveyor of the Local Board?—I do not think that the evidence of the Surveyor of the Local Board agrees with Mr. Easton's Report.

13,378. But the Surveyor of the Local Board is an official person, and he has given his evidence, and his statement is that there are 507 houses drained into the river through this sewer; are you prepared to say that the sewage of these 507 houses will cause the nuisance you have been speaking of to-day?—I am prepared to say that the sewage of 507 houses, being concentrated as it is, will cause a nuisance when discharged upon the middle of that mud; that is to say, if you were to discharge it in the middle of this table or this room it would be very disagreeable for everybody sitting round it.

13,379. Do you mean to say that the drainage caused by these 507 houses would amount to the nuisance you have been referring to to-day, and would account for the complaints of the people of Erith?—I say that the sewage of those 507 houses would account for the complaints of those men who were excavating a channel for Mr. Beadle, and I never said anything more than that.

13,380. Now you stated that last year, when you had such experience of the river, there was no smell from the river?—No.

13,381. Was there no smell from the Thames in Erith Bight last year?—No, I am positive of it.

13,382. That there was no smell?—That there was no smell, and everybody I talked to in Erith said the same.

13,383. And you say there was nothing offensive?—Nothing at all.

13,384. Nothing offensive either in the smell or the mud?—No, I say that last year I rather enjoyed myself there, except when I was in the middle of the sewage. Erith bight is a very delightful place to spend a summer in; you may laugh, but it is perfectly true; there is a very nice yacht club—a most popular yacht club there.

13,385. (*Chairman.*) Erith is a very nice place, is it not?—Yes, and there is a very nice yacht club there; it is becoming a very popular club. I have been invited frequently to go down there yachting on Sundays, but having been engaged all the week I prefer to spend my Sundays at home.

13,386. (*Mr. B. Morice.*) Do you know that there has been a tendency to silt up this place where you say the flushing takes place?—No doubt there is a tendency to silt up; but with regard to that excavation at the coal wharf that is quite recent.

13,387. In the examination of Mr. Beadle by the noble Chairman, he was asked, "But you said that it "was not necessary to do so a few years ago?" to which he replied, "Not as we must do it now; we "have to keep a gang of men sweeping it night and "day;" and in the previous question he was asked, "Was it only the last year or two that you have been "obliged to keep the place clear? (*A.*) No, we "always had a man in there to look after it; but "these last two years it has been almost impossible "to keep it clear"?—I quite agree with every word he says, and I can explain it. The foreshore low-water line has gone out at Erith Causeway an enormous distance within the last few years; every word that was said about that is perfectly right, and it is exactly what must take place on account of the slack water.

13,388. There is an increasing deposit of this mud?—Yes.

(*Chairman.*) I do not know what you mean when you say that the low-water mark has gone further out.

(*Mr. B. Morice.*) There has been an increased deposit of mud which sends the low-water mark further out.

(*Witness.*) But that is above the pier. Below Erith pier the foreshore has not gone out an inch since 1833, comparing it with the chart; but above Erith pier it is going out to this day, and I do not know

how far it will go out. Deposit at slack water must take place.

(*Sir John Coode.*) I understand this arises from dredgings upon the opposite shore?—I do not care to go into that; but I have many observations, and Mr. Law will put them in.

(*Sir John Coode to Mr. B. Morice.*) That is the point which is between you. You contend that that is due to the increase of the sewage, while the other side contend that it is owing to the dredging upon the opposite side.

(*Mr. B. Morice.*) And the question is also, not what caused it, but also what it is.

(*Sir John Coode.*) Certainly.

13,389. (*Mr. B. Morice to the witness.*) Are you aware that in the report upon the drainage system in 1857 it was stated that Erith reach would not be a good place to receive the sewage because it would silt up?—I am not.

13,390. Do you know as a fact that the accumulation in the bight near the Corinthian Yacht Club house is largely composed of sewage?—I know as a matter of fact that it is not.

13,391. You have heard the evidence of the man Lee, who is the man in charge of the yacht-house?—I have; he said it was "that which came from the "human frame." It is the greatest nonsense that any man ever talked about—he lives there, a great strong healthy fellow, with a lot of little children always playing about in the mud; it is absurd.

13,392. But he is living there, and should know all about it?—No doubt he should, but he talks about its being "what comes from the human frame"; it is the greatest nonsense in the world; it is just what does not come from the human frame.

13,393. You remember that Mr. Lee stated that some of his children had illness?—I do not remember that, but I know him well; I used to land there.

(*Chairman.*) How do you cross-examine this witness upon that footing?

(*Witness.*) It is the place where all gentlemen get into their boats, and leave their boats; it is a very nice place.

13,394. (*Mr. Beaumont Morice.*) You say there is no sewage in that bight?—The chemists can give you evidence about that.

13,395. But speaking popularly, as an ordinary observer?—Nobody speaking truly could say that there was sewage in that bight. Speaking ordinarily it will not smell of sewage.

Re-examined by Mr. Michael.

13,396. A very large number of samples of mud were taken for the former inquiry, and they were analysed by chemists?—They were.

13,397. And you took a large number of samples for determination whether the alleged sewage at those various places was sewage or not?—I did; I took a great number.

13,398. With respect to the time over which your examination of these various matters extended, how long last year did you practically live upon the river?—I was down there 59 days, between the months of May and November.

13,399. Had you a steamer?—I had most of the time.

13,400. Having made those observations, when were they reduced to writing?—Immediately after they were made.

13,401. And is this the proof which you have before you of observations which were made at that time?—It is.

13,402. (*Mr. L. Smith.*) Those are not the original observations?—No, not the originals.

13,403. (*Mr. Michael.*) As I understand, except these you only have your level book?—Yes.

13,404. Which you will produce here?—Yes.

Examined by the Commission.

13,405. (*Chairman.*) There is a question I wish to ask you upon which you have expressed an opinion. I understand you to say that there is what you call slack water always opposite to Erith?—Always at three hours after high water.

13,406. And you say the tide does not flow into it as it is flowing down the river?—No, it is coming by the point.

13,407. But when it is coming up the river, coming back, as it unfortunately does, diluted no doubt and mixed, but still when it comes back would it not flow into the bight?—I have not made any observations upon the flood tide.

13,408. But cannot you answer me?—I have no doubt it would go into the bight.

13,409. Then the sewage would be brought into the bight, would it not?—The composition of the banks along there is exactly the same as of the suspended matter in the water.

13,410. But that is no answer to the question—it is giving evidence upon a point upon which you disclaimed your competency, but it would be true, would it not, that the return sewage would come into Erith bight?—Yes, I have no doubt that the water coming up the river would.

13,411. (*Sir John Coode.*) Will Mr. Law's section show us how much the bed of the river has been dredged of late years?—He has got as much information as there is upon the subject; he has got comparative sections for the years 1833, 1861, 1879, and 1882.

13,412. It is rather important for the Commission to know what are the facts, in order that they may know what they should consider to be the proper weight of this contention as to the effect of this dredging in causing this deposit. It is contended, I believe, on behalf of the Metropolitan Board of Works, that this advance in the low water line is due to dredging upon the north side?—Yes.

13,413. And upon the other side it is contended that the deposit is caused by sewage, which you deny?—Yes, that is so.

(*Mr. Michael.*) We had a large number upon the former inquiry, and we have more now, of observations to show you the alterations in the shore, owing to the alteration of the sectional area. I think we shall be able to produce before you a series of contour plans which will show the periodical alterations of the river.

(*Mr. B. Browne.*) We want the level books put in, and the observations of 1877 and 1882.

(*Mr. Michael.*) They shall be put in.

The witness withdrew.

Dr. Theodore Maxwell called in and examined.



13,414. (*Mr. Michael.*) You are a Doctor of Medicine of Cambridge University?—I am.

13,415. And Bachelor of Science of the London University?—Yes.

13,416. And a Fellow of the Royal College of Surgeons, Edinburgh?—Yes.

13,417. And also a Fellow of the Chemical Society, and a holder of the Cambridge University Sanitary Science Certificate?—Yes, I am.

13,418. Have you for five years resided at Woolwich?—I have.

*Dr. T. Maxwell.*

23 May 1883.

13,419. Where does your practice extend over?—All over Woolwich and Plumstead.

13,420. (*Chairman.*) As practising medical man?—Yes.

13,421. (*Mr. Michael.*) Among what classes do you generally practise?—All classes. I have a good many club patients which comprise the working classes, and men who work in the arsenal and the different factories in the neighbourhood. I also attend many families of tradesmen and of officers, soldiers, and army pensioners.

13,422. And the river-side people who are working upon the river?—The arsenal is upon the river and a large number of people live very near the river; there are no houses actually upon the river side in Woolwich itself. I have sometimes attended people who live in North Woolwich, but I could not say that my practice extends to North Woolwich.

13,423. With respect to the diseases of a zymotic character, what do you say first with regard to typhoid fever and its prevalence in the district?—I have seen exceedingly little of it.

13,424. If it were present according to your experience would you be likely to see cases of typhoid fever and to know of it?—Very likely indeed. I cannot conceive of its being particularly prevalent without my knowing of it. During the five years I have been there, I have had in my own personal practice just three cases of undoubted typhoid fever.

13,425. Do you know what is the result of the practice of other medical practitioners in the district.

*Mr. L. Smith* objected to this question.

*The Chairman* allowed the question to be put.

(*Witness.*) I have seen one or two cases perhaps in consultation or when acting for some other medical practitioner which really did not occur in my own practice.

13,426. (*Chairman.*) You are of course upon friendly terms and communicate with the other medical gentlemen?—Yes.

13,427. And you hear from them the state of the place generally?—Yes, I do.

13,428. And you do not hear much talk about typhoid fever from them?—I do not.

13,429. (*Mr. Michael.*) With respect to diphtheria, have you had any cases of that?—I have seen since I have been at Woolwich, one case of undoubted diphtheria in my own practice; two or three weeks ago there was one at Shooter's Hill. I have also seen in consultation two other cases in the lower part of the town, and I have had under my own care a case which I believed to have been diphtheria, but about which there was some doubt, that is all I know about diptheria.

13,430. How far is Shooter's Hill from the river?—About two miles.

13,431. With respect to other diseases of the same class, scarlet fever and other diseases of that sort, are they prevalent according to your own experince?—I have nothing to remark about them. I do not think they are peculiarly prevalent, and I do not think they are less prevalent than they are elsewhere, but it would be extremely difficult to say. These include classes of cases in which doctors are called in and some in which they are not, according to people's fancies or to their means, so it would be extremely difficult to say whether there are more or less cases at Woolwich than in other places. I have no reason for thinking they are either more or less.

13,432. Has your attention been directed to the alleged presence of the sewage in the river, so that you could trace those cases of disease to the sewage in the river?—I know it is said that there is sewage in the river, and I know from personal experience that the river smells badly.

13,433. Have you any reasons to trace the diseases to the sewage?—I have been unable to do so.

13,434. (*Sir John Coode.*) Have you been able to trace the disease to any special cause?—The first case of typhoid fever was that of a clerk engaged in London, and I believe from what he said that the typhoid fever arose from defective sanitary arrangements in his office in London. I looked at his house in Woolwich, and I have no reason to think it came from there; and the only conclusion I could come to was, that it arose from the state of his office in London. Then, as to the other two cases I had in my own practice, they certainly did occur close to the river; they were the cases of a working man and his son, both of whom worked at some works upon the other side of the river, viz., at the Beckton Gasworks, and from inquiries I made of them at the time, the conclusion I came to was that the closet arrangements for the working population of Beckton were exceedingly defective. I knew of no other cases in the neighbourhood at the time, and the conclusion I came to was, that it had been caught from some cause or other over at Beckton.

13,435. Were those the only cases that you heard of, the clerk and the two men employed at Beckton?—I have had no others in my own practice.

13,436. (*Dr. Stevenson.*) Were those simultaneous cases, the father and the son?—They were almost simultaneous; the disease was almost evidently caught at the same time and place.

13,437. (*Mr. Michael.*) What is the general health of the people of Woolwich?—Very fair; it is, as far as my practice enables me to judge, as healthy as most places.

13,438. Have you ever been able to form any opinion as to the river exercising any injurious effect upon the health of the district?—I have never had any reason to think that it does so, and I have smelt it often enough.

13,439. Do you often cross the river yourself?—Sometimes I cross it frequently; sometimes a month goes by without my crossing it.

13,440. Do you exercise your practice constantly close to it?—I am constantly close to it; I was across it pretty often last summer, and I do not recollect noticing the smell very decidedly.

13,441. (*Sir John Coode.*) Do you live near the river?—No; I live upon the common, which is about a mile from it.

13,442. (*Chairman.*) And it is upon high ground?—It is on high ground.

13,443. (*Mr. Michael.*) But, as I understand you, your practice extends to the riverside?—Yes, it does.

13,444. Therefore, if there were any injurious influence, you would be likely to know of it?—I should be almost certain to know.

13,445. (*Chairman.*) At what distance from the river can you smell it; can you smell it at any distance, or only when you are upon the river?—I do not think I have ever smelt it except when I have been upon it, crossing in a ferry boat.

13,446. (*Sir John Coode.*) Have you ever smelt it at your own house?—There are manufacturing smells which I can clearly distinguish at my house, but I should not like to say that I have smelt the sewage there.

13,447. Some of the manufacturing smells are very strong indeed, are they not?—They are very strong indeed.

13,448. (*Dr. Stevenson.*) To what, in your opinion, do you attribute the smell of the river?—I have always supposed it was sewage in the river.

13,449. The smell reminds you of sewage?—Yes, I think it does.

13,450. (*Chairman.*) It is such as you would expect a sewage smell to be?—It is.

Cross-examined by Mr. L. Smith.

13,451. These two men you have referred to worked at Beckton; can you tell me the time of the year when they had that typhoid fever, and what year was it to begin with?—It was about three years ago. I cannot tell you whether it was in December or January; it was in the winter time. It was not in the summer I am positive.

13,452. They would have to cross the river twice a day, I suppose, to their work and back again?—Yes, they would, certainly.

13,453. You have told me, and I suppose it is the fact, that a great many of the poor do not call in doctors unless the illness is very serious?—That is so, only you must recollect that a large number of the patients I attend belong to clubs, and, therefore, they have the opportunity of calling me in for nothing.

13,454. With regard to scarlet fever, to which you have referred, is there a good deal of scarlet fever that goes on without medical men being called in?—I think there is not much, but there would be a good deal of measles. Many people have children with measles, and never think of sending for a doctor.

13,455. And, I suppose, *a fortiori* with diarrhœa?—Yes.

13,456. You heard Professor Corfield examined, perhaps. He seemed to think that the injurious effect of the river would show itself principally in scarlet fever, measles, and diarrhœa; would you agree with that?—I should not like to give an opinion about it.

13,457. Last year we have heard the river did not smell so much as on previous occasions?—I did not notice it particularly last year.

13,458. Have you practised elsewhere, or was this the first place you have practised in?—I practised in Hanwell for a year and a half, before I came to Woolwich, and before that I was in India.

13,459. Was there more typhoid fever before you came to Woolwich, do you know?—There was a considerable epidemic of typhoid fever before I came there, and I had to deal with one at Hanwell.

*Dr. T. Maxwell.*

23 May 1883.

Cross-examined by Mr. B. Morice.

13,460. Have you ever felt any illness yourself from this smell; I do not mean any serious illness, but any slight illness?—I cannot say that I have.

13,461. Have any of your patients had any illness of that kind without amounting to anything serious; nausea for example?—Many patients have, of course, nausea, which one cannot attribute to anything in particular, but I have never had occasion to attribute it to sewage in the river. I know I have heard patients attribute nausea and headache to the manufacturing smells that we get from the river.

The witness withdrew.

Mr. William Warman Coleman called in and examined.

13,462. (*Mr. N. Bazalgette.*) You are a member of the Royal College of Surgeons?—I am.

13,463. And you have lived for the last 26 years at No. 3, Plumstead Road, Woolwich?—Yes.

13,464. How far do you live from the river?—I live about 200 or 300 yards from the river.

13,465. First of all, will you tell us whether either you, or any member of your family, have experienced any ill effects by reason of your proximity to the river?—Not the slightest.

13,466. Have you been in practice in Woolwich during the whole 26 years?—I have.

13,467. I believe, for five or six years, you have been one of the doctors attending the Arsenal?—Yes.

13,468. And you are certifying surgeon for the district under the Factory and Workshops Act, 1878, are you not?—I am.

13,469. In the discharge of your duty, do you have constantly to visit factories and workshops?—Constantly.

13,470. In the course of your practice do you visit a great number of people who live upon the river bank?—Yes.

13,471. And you visit the families of working men?—I do.

13,472. Do you find zymotic diseases prevalent amongst your patients?—Certainly not.

13,473. Do you consider Woolwich a healthy town?—I should call it a particularly healthy town, considering the enormous population of Woolwich and Plumstead; it is all one place, in which the population is very large and the health very fair.

13,474. (*Sir John Coode.*) Do you know what is the average death rate over a period of seven years?—Unfortunately we have no statistics; though it is a very large town, and I daresay they have plenty of money, yet I think it is the only town in England where they have no medical officer.

13,475. (*Chairman.*) A part of Woolwich, I should suppose, is a naturally healthy place, it is high ground, and it is chalk and sand?—Yes, it is a nice gravel and sandy soil.

13,476. Could you discriminate between those higher parts and the lower parts in regard to the death rate?—Singularly enough, the greatest number of zymotic diseases have occurred across Plumstead Common, at a place called the Slades; they have the largest number of zymotic diseases at that part which is more remote from the river; whether due to defective drainage or not, I do not know. As a matter of fact, the lower part compares very favourably with the higher.

13,477. (*Mr. N. Bazalgette.*) Now I will ask you, with your experience, have you ever known a case of zymotic disease which has been produced by sewage in water, except where the mixture has been drunk?—I do not think I can call to mind one case that I have ever seen or heard of.

13,478. I believe you had eight cases of death amongst your patients in 1882?—Yes, I had.

13,479. Were any of those cases from zymotic disease or blood poisoning?—Not one.

13,480. Has the drainage of Plumstead Marshes had any effect upon cases of intermittent and typhoid fever in the parish?—A very great effect. Since the opening of the outfall sewer, many of these dykes have been drained, and now the marshes are very much more healthy than they used to be.

13,481. As you told the noble lord, you think that the cases of zymotic disease are, as it happens, more prevalent in the districts that are more remote from the river?—I cannot say that has always been the case, but I have noticed that recently.

13,482. Have you often seen the mudlarks playing about in the mud off Woolwich Arsenal?—Yes, I have.

13,483. Do you attend many of the poorer class of parents there?—Yes, I do; the boys are constantly bathing off the Arsenal the whole day long.

13,484. Have you ever had any cases of evil results arising from that?—Never, except from immersion and suspended animation when a boy has gone beyond his depth.

(*Chairman.*) He must have swallowed the mixture then, it would not be a case of the gas only.

13,485. (*Mr. N. Bazalgette.*) On the night of the

*Mr. W. W. Coleman.*

*Mr. W. W. Coleman.*

23 May 1883.

"Princess Alice" disaster what were you doing?—I was rowing about in a small boat, examining all the people who were picked up.

13,486. What were you doing the next day?—I was on board the "Heron" steamer, and we were picking up the bodies.

13,487. Were the bodies that were found put on board the "Heron" steamer before they were brought ashore?—Yes, they were.

13,488. Of course you saw them?—I did.

13,489. Did you see all the bodies that were brought on board the "Heron"?—I did.

13,490. Did you notice whether they were particularly muddy, or had the appearance of sewage about them?—No, not especially.

13,491. You have seen many cases of drowning, I presume?—Yes, I have.

13,492. Do you find as a rule that bodies which are taken out of the Thames are more or less always in a muddy condition?—Yes, always.

13,493. Did you ever notice any smell in the river?—Since I was first interviewed with regard to this matter, I have crossed the river by the ferry at low water to notice whether the paddles would stir up the mud particularly, and I have been surprised to see how little smell there really was.

13,494. Previously to your having paid special attention to that fact, had you ever noticed the smell from the river, passing it as a casual traveller?—No, never.

13,495. Have you noticed the smell from the factories in the neighbourhood?—Frightfully, at times.

13,496. Is that very bad?—Very bad, particularly at night, when the wind is in the east or the north-east.

Cross-examined by Mr. Balfour Browne.

13,497. You have said that since your attention has been directed to this inquiry you have noticed the smell, though you were surprised it was so little?—I was surprised to find so little smell, I expected to find more.

13,498. Why did you expect to find more?—I had heard so much of the offensive state of the river.

13,499. Did you hear that from your patients?—No, from reading the newspapers and hearing of what was going on.

13,500. Going on where?—At the examinations and in various places.

13,501. What papers were you first referring to when you said newspapers?—The daily papers, and I have seen boats floating by with people taking samples for an examination of the Thames water.

13,502. But you say you have seen accounts in papers speaking of examinations; what examinations were those; the reports are not published of this Commission?—They are not published verbatim, but you get sufficient hints of what is going on to have an idea, and when I was going to be examined with regard to this matter I took the trouble to go down to the riverside to see it myself.

13,503. Did you ever try whether the mud upon the banks of the river smelt offensively?—I have been down there sometimes and have not noticed it.

13,504. But you have been there sometimes and have noticed it, I suppose?—Very slightly indeed.

(*Chairman.*) This gentleman is giving his evidence in an excellent manner, and I would ask you, do you think you can make a good affirmative witness out of him?

13,505. (*Mr. B. Browne*). No, I do not think I can. (*To the witness.*) What diseases would you expect to find alongside of a river into which large quantities of sewage had been poured?—Typhoid fever and scarlet fever.

13,506. I thought you said zymotic diseases were never communicated from water, in your experience, unless the water were drunk?—Not from the water, but from the residue which remains upon the bank of the river.

13,507. If there be a deposit formed upon the bank of a river; that deposit might cause typhoid fever, and the typhoid fever might be communicated to other places, is that so?—It might be.

13,508. (*Sir J. Coode.*) How do you think it might be communicated?—You are aware that, when the sun plays upon a bank where you have noxious matter exposed, you have emanations given off which no doubt more or less poison the air.

13,509. Would you think that the germs of disease would be conveyed from that through the air?—It is a very doubtful point. I very much doubt whether the great physiologists agree upon that matter.

13,510. (*Mr. B. Browne.*) I am not asking, nor is Sir John Coode asking, what great physiologists would agree upon, but have you not found in your own practice that zymotic diseases have been conveyed by sewer gas?—Yes, undoubtedly by sewer gas.

13,511. Therefore the germs or the factors of the disease must be carried by means of the air?—Yes, undoubtedly.

13,512. Therefore, if noxious matter were deposited upon the bank or the shore, it would be carried by the air to the people along the banks?—I do not know that, because I have had one man living upon the bank who has resided there 19 years with his family, who has had no cases of that kind in his family.

13,513. But do you mean to say that one man is a criterion?—No, but there are other families which have no case of disease. This man I am now speaking of has resided at No. 1 Land Magazine, upon the marshes, 19 years, and has never had a case of disease in his family from that cause.

13,514. Have you compared the death-rate in the parishes by the banks of the river with the death-rate in the parishes not affected by the river?—I have not done so.

13,515. Have you ascertained whether diarrhœa, measles, and typhoid fever, are more frequent in the riverside parishes than in other parishes?—I have not gone into that.

13,516. (*Sir J. Coode.*) This is a very important point, and I am not quite sure whether I rightly understand Dr. Coleman's evidence; he meant that typhoid fever might be communicated by gas emanating from a sewer, but do you think the same would apply to emanations from river banks under a hot sun?—I do not know so much about that, that would be a moist vapour more than anything else.

13,517. You would be more sure about sewer gas than the gas from a deposit on the banks?—I should not like to give an opinion upon the last point.

13,518. That, as you say, is a moot point between the highest authorities?—Yes, I believe so.

13,519. (*Mr. B. Browne.*) Do you think that, because there would be a larger proportion of moisture in the atmosphere, that would render the germs innocuous?—No, I do not say that, but I think it would be more doubtful than in the case of sewer gas.

(*Chairman.*) The witness has come prepared to speak to matters within his own knowledge, and we shall have scientific witnesses who, as I understand, will come prepared with such evidence as you are now endeavouring to get from this gentleman, and he might very fairly say, Do not ask me about this, I have not studied this matter.

13,520. (*Mr. B. Browne.*) If he says he would not express an opinion, that would be a different thing. (*To the witness.*) Have you seen the Report of Messrs. Bidder, Hawkesley, and Bazalgette, upon this matter?—I have not.

13,521. In fact, you have not prepared yourself in any way to give evidence?—I have not. I did not

know I was coming up here as a witness till yesterday afternoon.

13,522. The conclusion those three gentlemen came to was, "The condition of the stagnant mud is injurious to health,"—you would not agree with that?—I would rather not answer that question.

*Mr. W. W. Coleman.*

23 May 1883.

Re-examined by Mr. MICHAEL.

13,523. A thing may be injurious to health, I suppose, without creating zymotic disease?—Undoubtedly.

13,524. Whether it is communicated by germs or by gas, is the condition the same of gas given off by sewage in a closed sewer, and of gas or vapour given off from the banks into the open air, where it is diffused in an immense bulk of air?—No doubt, there is that difference.

13,525. May there be something bad given off from mud without its being productive of zymotic disease, either typhoid fever, measles, or scarlet fever?—Undoubtedly.

13,526. As I understand, you do not want to give any opinion as to what is the special origin of zymotic disease?—I would rather not give an opinion upon a matter of that nature.

Examined by the COMMISSION.

13,527. (*Dr. F. de Chaumont.*) Have you been aware of any change in the general condition of the health of the district before and after the outfall?—I find a very remarkable change. Operations I had to perform many years ago were very frequently followed by intermittent fever; that was while the marshes were full of foul water, and the same thing was the case with regard to confinements.

13,528. Do you wish to make us understand that the general tone and health of the district has rather improved than otherwise since the opening of the outfalls?—I believe so, greatly.

13,529. There has been no deterioration since the establishment of the outfalls, at all events?—Not the slightest.

13,530. Did I understand you rightly as saying that there was no medical officer at Woolwich?—Not one.

13,531. (*Colonel Ewart.*) You stated that you had, since you were interviewed, more closely observed the river; when did that interview take place?—I dare say six weeks or two months ago, and that drew my attention to it more particularly in the first instance.

13,532. Your examination did not extend to the hot season of last year?—No, but six weeks ago my attention was drawn to the matter, and, thinking the question might arise, I went down to see some patients of mine who live upon the river bank, and I also went across the ferry at low water more frequently to see the effect when the water was stirred up by the paddles of a steamer.

13,533. And that was within the last two months?—Yes.

13,534. (*Dr. Stevenson.*) You spoke of the bodies taken out of the river after the "Princess Alice" disaster, and compared them with other bodies found in the river; from what other portions of the river were those others taken?—They were mostly the bodies of people who had fallen in from vessels, or from swimming and getting out of their depth.

13,535. But in the same locality?—Yes, mostly, just by the arsenal.

13,536. You have not observed the condition of bodies taken from other portions of the Thames?—I have not.

13,537. Do you know in what time decomposition set in in the bodies that were recovered after the "Princess Alice" went down?—From their all dying in good health and in full habit of body, decomposition would set in more readily than it would in ordinary cases of death, but moreover you will remember, that that was a warm September, and I think that had a great effect.

13,538. Were the bodies black?—No, the faces were all turgid and bloated, as is invariably the case in cases where animation is suspended suddenly.

13,539. It was given in evidence that the bodies were in a very offensive condition in two days, was that so according to your experience?—That would be so in the cases of many of the more obese people, as decomposition sets in so suddenly.

13,540. (*Chairman.*) Does your practice extend at all in the direction of Erith?—I go up the marshes frequently. I have been down there to see people who have removed in the direction of Erith from Plumstead, they having been my old patients.

The witness withdrew.

(*Mr. Chatterton's Level Books were handed in for examination.*)

Mr. F. LETT called in and examined.

13,541. (*Mr. Michael.*) You are a member of the Royal College of Surgeons of England, a licentiate of the Royal College of Physicians of Edinburgh, and a Licentiate of the Society of Apothecaries also?—Yes, I am.

*Mr. F. Lett.*

13,542. And you reside at 32, Rectory Place, Woolwich?—Yes.

13,543. How far is that from the river?—It is about a quarter of a mile from the river.

13,544. How long have you been there?—About 11 years.

13,545. You practise as physician and surgeon, I presume?—Yes.

13,546. And you are one of the district medical officers to the Woolwich Union?—Yes.

13,547. In what part of Woolwich do you practise?—Near the centre of the town, I think.

13,548. Does your district extend from the side of the river to Woolwich Common?—Yes, towards the top of Woolwich Common from the riverside.

13,549. Have you many patients among the labouring classes employed upon the river and residing near it?—Yes, residing near it, certainly, and upon it too.

13,550. Have you had any cases in your practice that you could trace to the presence of sewage in the river?—No, not distinctly traceable.

13,551. What is the general ratio of zymotic disease in your practice, as compared with the ordinary ratio of zymotic disease to other diseases in the country?—I consider it is low comparatively.

13,552. Have you cases of typhoid fever?—I have had some.

13,553. And diphtheria?—Yes.

13,554. And diarrhœa?—Yes.

13,555. Have you had any cases of scarlet fever?—I have.

13,556. And measles?—Yes.

13,557. With respect to all those diseases, have you ever had any case that could be traced to riverside occupations?—No, I have not.

13,558. Have you had occasion to look at the river with respect to its sanitary condition?—No, I do not know that I have been called in officially to do that, though I have had opportunities of judging.

13,559. But have you used your opportunities, have you considered in your practice whether or not the condition of the river had any effect upon the general

*Mr. F. Lett.*

23 May 1883.

health?—I have not been able to trace that it has had any deleterious effect upon the health of the inhabitants.

13,560. In your opinion, what is the general health of the inhabitants?—Very fairly good.

13,561. Have you been able to smell the sewage in the river in hot weather?—Yes.

13,562. Did you during the last year?—I am not sure that I did during the last year.

13,563. Have you formed any opinion as to whether the deposit, upon the banks of the river, of the mud has occasioned any disease?—I have not been able to trace any disease from it.

13,564. Whether zymotic disease or otherwise?—Whether zymotic disease or otherwise.

13,565. Do you think that sewage in water could create zymotic disease; I do not mean drains, but flowing along past the district?—Really, I would not like to answer that question.

13,566. Have you any smells from factories in your district?—Yes.

13,567. Are they offensive?—Certainly.

13,568. (*Chairman.*) Are they productive of disease?—I would not like to say that, but certainly they are very disagreeable, and smelling very strong indeed at times.

13,569. Just let me interpose this question: have you had this sort of thing happen to you, that your patients say to you, We seem to have been very poorly. There has been a good deal of diarrhœa and a tendency to nausea, so that people, without having a sufficiently specific complaint to come to a doctor for, would be uncomfortable. Do you have anything of that sort?—Nothing to call for any special remark upon my part.

13,570. When you say you have smelt the river yourself, has the sewage smell been to such an extent as to be merely unpleasant to those who have to smell it, or injurious to their well-being?—It would be very unpleasant, and, in the hypothetical case of people being already in ill-health, it might be to a certain extent injurious, or of a prejudicial character; but I could not give any specific instances within my own knowledge.

13,571. (*Mr. Michael.*) Upon the shore of the river or inland?—What I am now saying would, I think, apply to the river side.

13,572. Have you ever been able to divide your practice into two zones, the riverside zone and the inland zone, so as to enable you to say whether this is more unhealthy than that?—I have not been able to do that.

13,573. (*Sir John Coode.*) Have you ever thought of that before?—Not until lately, but I have had so much to do with it, that I should be able to remark it if such a thing had existed.

13,574. (*Mr. Michael.*) Would you have been able to record whether one zone was more remarkably unhealthy than the other?—Certainly.

13,575. With regard to the diseases supposed to be derived from bad air and bad water, have they been of such prevalence near the river as to draw your attention to them?—They have not.

Cross-examined by Mr. Lumley Smith.

13,576. Have you in all cases been able to trace these diseases of typhoid fever, diarrhœa, and measles, to the river?—No.

13,577. Have you been able to trace them to any cause, or has the origin of them been left untraced in most cases?—It has remained untraced in most cases.

13,578. With regard to the class of people who live nearer the river, are they of a poorer class than those who live further back?—They are of a poorer class, no doubt.

13,579. And for that reason, being poorer, they would be less likely to call in medical attendance?—I am medical officer of the Union, and they have medical attendance gratuitously.

13,580. But with regard to what the vicar of Plumstead described as being a diminution of the *vis vitæ*, they would not be likely to call in the assistance of the medical officer in such a case as that, would they?—But then, you see, the medical officer has the power to order other things besides medicine, which are very much desired by the poorer classes, such as aliment.

13,581. But clubs are not very liberal in these matters, are they?—But I am the medical officer for the Guardians, and I have the power to order many more things other than medicines.

13,582. (*Chairman.*) Your work is not piece-work; it is not your interest not to diminish your patients?—No, not at all.

13,583. You are paid a salary, I take it?—Certainly.

13,584. (*Mr. Lumley Smith.*) As regards such ailments as the vicar of Plumstead described, the people would be hardly likely to come to the district medical officer, would they?—I think they would in many cases.

13,585. Now, with regard to what you told us, that the effect of the river would be injurious to persons in ill-health?—I meant that anything of a disagreeable nature would more affect persons of a delicate constitution and weak persons than strong people; that was the sense in which I meant it would affect them.

13,586. (*Dr. Stevenson.*) Have you had an opportunity of comparing your district, medically speaking, with other districts; have you practised in any other part?—I have not practised in any other part, or very little.

13,587. Have you any reason to suppose that these sensations of nausea are more prevalent in your district than in others?—I am not aware of that.

13,588. Have you no reason to believe it?—It has not been brought before me.

13,589. You do not think such cases are more prevalent there than elsewhere?—It has not been brought before me, and I have no reason to think so.

The witness withdrew.

Dr. Alfred Rowarth called in and examined.

*Dr. A. Rowarth.*

13,590. (*Mr. N. Bazalgette.*) You are medical officer of the "Exmouth," are you not?—I am.

13,591. Where is the "Exmouth" stationed?—Off Grays.

13,592. Do you live at Grays?—Yes.

13,593. Do your duties constantly take you on board the "Exmouth"?—I go on board every day excepting Sunday.

13,594. Therefore every day you have opportunities of judging of the state of the river?—Yes.

13,595. Will you tell us first of all whether you have ever observed any traces of sewage in the river?—I never have.

13,596. Have you ever observed any smell from the water?—None.

13,597. How about the banks; have you ever observed any smell from the banks?—Not of sewage.

13,598. Have you observed anything beyond what you experience from mud banks as a general rule?—Not anything.

13,599. Do the boys of the "Exmouth" bathe in the river?—In the summer months.

13,600. And do they have a bath on board the ship which is filled from the water of the river?—Every morning.

13,601. Do you bathe yourself?—Occasionally.

13,602. I need hardly ask whether you would bathe in your own practice, if you thought there was sewage in the river at that point?—I do not think I should.

13,603. Have you ever seen anything perceptible in the state of the water which would lead you to suppose that sewage was discharged at a point higher up?—No, I have not.

13,604. What is the health of the "Exmouth" boys?—It is very good indeed.

13,605. Is fever or diarrhœa distinguished by its absence on board?—It is.

13,606. (*Sir John Coode.*) How long has the "Exmouth" been where she is now anchored?—I think about 11 or 12 years. I have been in connexion with the "Goliath" and "Exmouth" for the last 11 years.

13,607. (*Mr. N. Bazalgette.*) How many boys are there on board?—There are between 500 and 600.

Cross-examined by Mr. Balfour Browne.

13,608. At what age are the boys received on board the "Exmouth"?—Twelve is the youngest.

13,609. And at what age are they discharged from the "Exmouth"; how long do they remain?—Until they are 15, not over 15.

13,610. Those are peculiarly healthy ages, are they not?—But they are not healthy boys when they are admitted, they are just the contrary.

13,611. As I understand you, you row out to the ship every day?—Every day.

13,612. Do you mean to say that you never detect any smell of sewage in the river?—Never.

13,613. Not even in hot weather?—Never.

13,614. You say you have detected the smell from the mud, but not what you would expect from the sewage; what kind of smell was it?—An earthy kind of smell, not an unpleasant smell.

13,615. If it occurred in hot weather, does not that look as if it were due to some decaying matter rather than to earth?—It is not a disagreeable smell; there is a difference between what I should call a sewage smell and an earthy smell; I could detect the difference directly.

13,616. Now Purfleet is where the "Arethusa" is stationed, is it not?—No.

13,617. Where is the "Arethusa" stationed?—She is at Greenhithe.

13,618. Is not there one of the vessels opposite Purfleet?—Yes, the "Cornwall."

13,619. Do you know that they complain very much on board the "Cornwall" of the river, and of the smell of the mud?—I dare say they do; I should say it is very bad indeed on Board the "Cornwall" at Purfleet.

Cross-examined by Mr. Beaumont Morice.

13,620. Do you know whether it is bad at Greenhithe?—I do not know whether it is bad at Greenhithe.

13,621. Do you know that on board the "Arethusa" they complained?—No, I do not know that; my observations have been confined exclusively to Grays, except that now and then I have been to Purfleet and have seen that the river was not so clear at Purfleet as it was at Grays.

Examined by the Commission.

13,622. (*Chairman.*) How many miles are you above Gravesend?—I do not know exactly how many miles, but I should think from four to five.

13,623. Is Gravesend still a bathing place; it used to be a bathing place at one time?—There are baths there, but I do not think the people bathe in the river there now, because there is no convenience for it.

13,624. Have you noticed the water at Grays at low water?—Yes, at all times.

13,625. Is it even then sweet enough to bathe in?—I have bathed upon the lowest ebb tide.

13,626. Without any consciousness that you were bathing in foul water?—Yes, I should prefer to bathe at the top of the flood, of course.

13,627. It is salter of course then?—Yes, it is.

13,628. Is that your only reason?—It is clearer.

The witness withdrew.

(*Mr. Michael.*) I have exhausted my four witnesses, and I now propose to read the extracts from the papers relating to Erith. You know we agreed that the Report from Mr. Easton, and a variety of other reports in connexion with Erith, should be put in, and, as I mentioned to your Lordship at the commencement of our sitting, it would be necessary to direct the attention of the Commission to those matters which we have extracted from a very voluminous mass of papers—they are before you—it would take much longer than 20 minutes to read them, but if you like, I will commence reading them now.

(*Sir J. Coode.*) Is this the residuum?

(*Mr. Michael.*) Yes, and I propose to read these extracts. These are matters agreed with the Erith people; we have gone all over the papers belonging to Erith, and these are papers which we think are of importance, and we have mutually agreed that they should be laid before the Commission.

(*Chairman.*) Then I should say, the sooner we begin it, the better.

(*Mr. Michael.*) My learned friend Mr. Bagalzette will read them.

(*Mr. N. Bazalgette.*) The first is a Report by Mr. Edward Easton.

(*Chairman.*) I think we had better first understand exactly what the papers are.

(*Mr. Michael.*) Erith has appeared here specially to make a complaint against the Metropolitan Board of Works; a great deal of correspondence had taken place, and a great many matters had been discussed at Erith with respect to the getting rid of certain difficulties which they have experienced with respect to drainage and other matters; a great deal of that we thought it was unnecessary to bring before the Commission, or to trouble the Commission with, and therefore my learned friend Mr. Beaumont Morice, and myself went over the whole of the documents to see those things which I considered material, and that he might see that I did not make any undue selection, leaving out other matters which would in any way modify those things which I had selected. It was agreed that the documents so selected should be put in before the Commission, but I knew that if they were put in the Appendix they might entirely escape the notice of the Commission, and I therefore proposed that they should be read. I think, mainly, they may be divided into three heads; a gentleman called Easton, who will subsequently appear as an engineer on behalf of the Metropolitan Board of Works, was called in by the Erith Local Board for the purpose of advising them with respect to their drainage, and many of these documents are reports addressed by Mr. Easton to the Erith Local Board. Besides that,

22 May 1883.

there are some reports of the Surveyor, and there are also reports and letters addressed to the local board with respect to nuisances arising on the banks of the river, other than the nuisances complained of, with respect to the river itself. Those are the three heads under which the evidence may be divided.

(*Chairman.*) You put these letters as a sort of evidence against Erith, saying, as it were, Erith has done this, that, and the other, and we put this in against you.

(*Mr. Michael.*) It will modify the evidence which Erith has put in, and will explain what it is essential the Commission should know. I can put it generally in this way. Erith says, The whole of the complaint that we make is against the river. Now these documents show that these matters of which they complained arose from the drainage of Erith itself, and from other matters, and those are matters which arose upon the cross-examination of their witnesses, and which they agreed to put in. There are many documents which they offered to produce, and which they undertook to produce.

(*Chairman.*) I understand that the principle upon which these are put in is that Erith has said and done this, that, and the other, and it is proposed to put in this against Erith.

(*Mr. B. Morice.*) Yes, but if you will allow me to say so, my learned friend Mr. Bidder, or my learned friend Mr. Michael, in cross-examining, was anxious to know if there were not any complaints to the Erith Local Board of the factories in the neighbourhood. It was stated that there was correspondence with respect to the factories, and the Chairman, then Sir Benson Maxwell, asked if there would be any objection to putting in this correspondence. We stated we would be perfectly willing to put forward, for the purpose of my learned friend, any correspondence which had taken place with regard to the factories.

(*Mr. Michael.*) But that is a very small portion of it. We asked if it were not the fact that Erith had been endeavouring for years to remedy grave defects which had existed with respect to the drainage and the drinking water. Erith alleged that it had suffered, owing to the sewage poured in by the Metropolitan Board of Works, and we asked, Was it not the fact that your people have suffered from your own bad drainage, and your local arrangements, and did you not call in Mr. Easton? I ask permission now to read the first letter from Mr. Easton to their own local authority, which will put the Commission at once *au courant* as to the whole of these matters.

(*Chairman.*) I am doubtful about it, because the right thing to do would be to call Mr. Easton and ask if he proposed to do one thing or another.

(*Mr. Michael.*) I propose to call Mr. Easton by-and-bye.

(*Mr. B. Morice.*) My clients were anxious to withhold nothing from the Commission, but, on the contrary, to give them every information in their power, and that is what we do here.

(*Mr. Michael.*) You will remember that Mr. Jessett was examined, who was one of the local officers of health, and he was asked if he did not make reports upon the health of the place to the Local Board, and here we have the reports, not only of Mr. Easton, but of the Surveyor, and of Mr. Jessett, and of others.

(*Chairman.*) If that is agreed to, we must read these documents.

After an informal discussion, it was ordered that, in the first place, the documents be printed as an Appendix.

Adjourned to Tuesday next, at half past 12 o'clock.

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# THIRTY-FIFTH DAY.

## Tuesday, 29th May 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
WILLIAM POLE, Esq., F.R.S., *Secretary.*

Mr. HENRY LAW, Memb. Inst., C.E., called in, examined by Mr. NORMAN BAZALGETTE.

*Mr. H. Law, M. Inst. C.E.*

29 May 1883.

13,629. You are a member of the Institution of Civil Engineers?—I am.

13,630. And a member of the Council of the Sanitary Institute of Great Britain, and a Fellow of the Meteorological Society?—Yes.

13,631. When did your acquaintance with the River Thames commence?—In 1837. I was then articled to Sir Isambard Brunel who was constructing the Thames Tunnel.

13,632. Did the nature of that work render it necessary that you should acquaint yourself with the movements of the tide and the conditions of the river bed?—Yes; it was so important to know what was going on in the river that we always had one of the engineers afloat to communicate with the engineer in charge of the tunnel below; we had signal poles for the day and lamps at night, so that if it were reported that water was coming in at a particular part of the shield the engineer was communicated with.

13,633. (*Chairman*) You had, in short, occasion to watch the tides?—Yes, I had occasion to watch the tides carefully, and to make daily observations upon the river.

13,634, (*Mr. Norman Bazalgette.*) Then upon the conclusion of the Thames Tunnel, I believe, you became chief assistant to the late Mr. Thomas Page?—I became chief assistant to the late Mr. Thomas Page, who was the chief acting engineer of the Thames Tunnel, and I made the working drawings under him for Westminster Bridge.

13,635. Was Mr. Page then employed in making drawings for the embankment of the Thames?—Yes, he was engaged in making drawings for the embankment of the Thames, and I, as chief assistant, was employed in making the plans for that work; the plans for the Thames Embankment must have been made in the years 1843 and 1844.

13,636. Did you, when those plans were being prepared, and in order to their being prepared, take a considerable number of soundings of the river?—Yes; soundings had been taken in 1796 by Capt. Shields, and in 1823, by Mr. Telford, extending from

Chelsea to Blackwall—it was 10 years before the removal of London Bridge—and in 1843 I took sections over the same lines for the purpose of comparing with the former soundings and seeing what change had been occasioned by the removal of London Bridge.

13,637. Can you tell me roughly how many sections you took between those points?—I cannot tell you the number at the moment, but I shall have occasion to produce them.

13,638. But I can put the figure to you; I have it that you took 61 sections?—Yes, I took quite that.

13,639. I believe that at the time you were with Mr. Page, all applications for leave to execute work upon the foreshore of the river had to be referred to Mr. Page, had they not?—Yes, proceedings had been taken in the Court of Chancery, in a matter between the Government Board of Works and the City of London, who were Conservators of the river, as to the ownership of the soil, and an interim order was made that before sanction for any works was given by the Conservators, a veto should be permitted to the Board of Works.

13,640. Did you when these applications came in, as Mr. Page's engineer, make the necessary local examinations?—Yes; I had occasion to visit all the spots, wherever they might be in the river, and to make the necessary examination.

13,641. I believe that in addition to preparing those plans for the embankment of the Thames, when you were with Mr. Page you also prepared plans for certain bridges across the River?—Yes, for the Chelsea Suspension Bridge, which was built by Mr. Page; for the Westminster Bridge, which was built by him, and for other bridges; one at Charing Cross, and one at Lambeth, where the present suspension bridge is; and I also had charge of two bridges which were built over the Thames at Windsor; the Victoria and Albert Bridges at Windsor were built under my direction.

13,642. Then I may take it generally that under this experience you acquired intimate knowledge of the Thames?—Yes, I did.

13,643. Have you read the whole of the evidence which has been given before the present Commission?—I have either read or heard it given.

13,644. Have you examined the whole of the plans and documents which have been put in?—Yes.

13,645. Now, I will ask you, first of all, what your view is with regard to the sufficiency and efficiency of the existing system of metropolitan drainage?—I heard the evidence which was given by Mr. Baldwin Latham, the general tenour of which was that the increase of London had outgrown the proportions of the drainage system, and that, in consequence, whenever any rain fell, it became inevitable that that rain would be discharged at one point or another by the storm overflows. I went very carefully into the matter to determine how far that was the case.

(*Chairman.*) I should very much like to know, as Mr. Baldwin Latham is here, does he agree that that was the tenour of his evidence (*to Mr. Baldwin Latham*). Do you agree that that was the tenour of your evidence?

(*Mr. Baldwin Latham.*) That was not the only point.

13,646. As far as Mr. Law has gone, is it correct?

(*Mr. Baldwin Latham.*) That is one of the points, but it needs qualification, because I pointed out as well that another cause of insufficiency was that the western district had been brought into the metropolitan drainage area.

13,647. (*Mr. Norman Bazalgette to the witness.*) Mr. Baldwin Latham has admitted that that was his meaning as far as your remark goes; will you now continue?—This plan (*handing in diagram No. 22, Appendix N.*) shows by the heavy dotted line the district of the Metropolitan Board of Works—the coloured portions are those which are drained; it will be seen that some portions of the district of the Metropolitan Board of Works are left white and are not drained.

13,648. (*Chairman.*) That is upon the south side, is it not?—Yes, both upon the south and upon the north, Hackney Brook, North Woolwich, figure 79, and a considerable area in the neighbourhood of Eltham. The district coloured red is that drained by he High Level sewer. The district coloured green is that drained on the north side by the Middle Level sewer; and on the south side by the Outfall Sewer; and the district coloured blue is that drained by the Low Level sewer. In order to ascertain precisely the work which each of those sewers, the High, the Middle, and the Low Level sewers, has to perform I have divided the several districts, which are each distinguished by separate numbers, according as they are drained into one or the other system. I have divided the population accordingly. I may as well give the whole population. Mr. Baldwin Latham, in his evidence, took the population of registration London as being more or less identical with that of what I may term drained London. Registration London, at the time of the census in 1881, contained 3,814,571 persons. I have, in a table, the number upon the North and South side, which I need not give separately, whereas Metropolitan London, which is not quite the same, contained 3,832,441.

13,649. (*Sir John Coode.*) Is what you call Metropolitan London that part within the black dotted line?—Yes; there are about 20,000 more persons in the district of the Metropolitan Board of Works than in the Registrar-General's District.

13,650. (*Chairman.*) We need hardly trouble ourselves with such a small fraction as that, need we?—No, but then I am going on to the district drained which contains 3,880,102. That I have divided into the portions coloured red upon the north, being those drained by the High Level, which contains 256,329, that drained by the Middle Level sewer containing 1,209,081, and that drained by the Low Level sewer containing 1,130,644 persons, The figures upon the south side I also have here, and, as I propose to put the table in, I do not know that I need read them, because I am dealing in these observations with the northern side, as that was the side which Mr. Baldwin Latham alleged during one year had really only discharged the sewage and allowed the whole of the rainfall to go into the river.

*Table No. 1 was handed in, and was as follows:—*

POPULATION of the METROPOLIS in 1881.

| | North of the Thames. | South of the Thames. | Total. |
|---|---|---|---|
| Registration London - - | 2,548,993 | 1,265,578 | 3,814,571 |
| Metropolitan London - - | 2,548,993 | 1,283,448 | 3,832,441 |
| Drained London - - - | 2,596,054 | 1,284,048 | 3,880,102 |

| | |
|---|---|
| *On the North side of the Thames:* | |
| Draining into the High Level Sewer - - - | 256,329 |
| " " Middle Level Sewers - - - | 1,209,081 |
| " " Low Level Sewer - - - | 1,130,644 |
| | 2,596,054 |
| *On the South side of the Thames:* | |
| Draining into the High Level Sewers - - - | 331,851 |
| " " Low Level Sewers - - - | 857,785 |
| " " Outfall Sewer - - - - | 94,412 |
| | 1,284,048 |

*Note.*—The population of North Woolwich is included in the numbers for the South side of the Thames.

I have here another table which I need not read, but the table contains, first, the numbers of reference to the plans; it is then divided into three columns, which give the population draining into the Middle, the High, and the Low Level sewers respectively for each of the districts, and therefore affords data for arriving at the quantity of sewage. Table No. 3 contains the same for the south side.

*Tables No. 2 and 3 were handed in, and were as follows:—*

*Mr. H. Law, M. Inst. C.E.*

29 May 1883.

POPULATION of the DISTRICTS drained on the NORTH SIDE of the THAMES in 1881.

| District. | Population draining into | | | Total Population in 1881. |
|---|---|---|---|---|
| | High Level Sewer. | Middle Level Sewer. | Low Level Sewer. | |
| 1. St. Mary, Paddington | — | 69,785 | — | 69,785 |
| 2. St. John, Paddington | — | 29,850 | 7,463 | 37,313 |
| 3. Kensington Town | — | 6,006 | 114,121 | 120,127 |
| 4. Brompton | — | — | 42,797 | 42,797 |
| 5. Hammersmith | — | — | 71,916 | 71,916 |
| 6. Fulham | — | — | 42,895 | 42,895 |
| 7. Chelsea | — | 2,643 | 85,458 | 88,101 |
| 8. Hanover Square | — | 13,653 | 16,686 | 30,339 |
| 9. Belgrave | — | — | 59,178 | 59,178 |
| 10. St. John, Westminster | — | — | 35,482 | 35,482 |
| 11. St. Margaret, Westminster | — | — | 24,604 | 24,604 |
| 12. St. James, Westminster | — | 16,415 | 13,450 | 29,865 |
| 13. St. Ann, Soho | — | 16,591 | — | 16,591 |
| 14. St. Mary, Marylebone | — | 87,673 | — | 87,673 |
| 15. Christchurch, Marylebone | — | 33,691 | — | 33,691 |
| 16. St. John, Marylebone | — | 33,640 | — | 33,640 |
| 17. Hampstead | 22,718 | 22,718 | — | 45,436 |
| 18. Regent's Park | — | 39,103 | — | 39,103 |
| 19. Tottenham Court | — | 27,728 | — | 27,728 |
| 20. Gray's Inn Lane | — | 30,229 | — | 30,229 |
| 21. Somers Town | — | 34,355 | — | 34,355 |
| 22. Camden Town | — | 17,406 | — | 17,406 |
| 23. Kentish Town | 21,847 | 65,541 | — | 87,388 |
| 24. Islington, West | 30,343 | 91,031 | — | 121,374 |
| 25. " East | 40,314 | 120,940 | — | 161,254 |
| 26. Stoke Newington | 5,695 | 17,085 | — | 22,780 |
| 27. Stamford Hill | 8 074 | 731 | 451 | 9,256 |
| 28. West Hackney | 18,800 | 18,800 | — | 37,600 |
| 29. Hackney | 34,599 | 26,910 | 15,377 | 76,886 |
| 30. South Hackney | 33,896 | — | 5,982 | 39,878 |
| 31. St. Giles | — | 45,257 | — | 45,257 |
| 32. St. Martin-in-the-Fields | — | 698 | 16,749 | 17,447 |
| 33. Strand | — | — | 16,067 | 16,067 |
| 34. St. George & St. Andrew | — | 11,950 | 23,900 | 35,850 |
| 35. Clerkenwell | — | 65,568 | 3,451 | 69,019 |
| 36. City Road | — | 31,232 | 15,615 | 46,847 |
| 37. St. Botolph | — | — | 11,168 | 11,168 |
| 37a. Cripplegate | — | — | 7,185 | 7,185 |
| 38. London City | — | — | 19,218 | 19,218 |
| 39. St. Bride's | — | — | 13,735 | 13,735 |
| 40. Shoreditch | — | 11,166 | 11,167 | 22,333 |
| 41. Hoxton | — | 57,954 | — | 57,954 |
| 42. Haggerstone | — | 46,278 | — | 46,278 |
| 43. Hackney Road | — | 52,709 | 26,355 | 79,064 |
| 44. Bethnal Green | 12,000 | 20,628 | 15,314 | 47,942 |
| 45. Whitechapel | — | — | 71,350 | 71,350 |
| 46. St. George in the East | — | — | 47,011 | 47,011 |
| 47. Limehouse | — | — | 58,500 | 58,500 |
| 48. Mile End | — | — | 105,573 | 105,573 |
| 49. Bow | 5,569 | 18,530 | 12,961 | 37,060 |
| 50. Bromley | — | — | 64,345 | 64,345 |
| 51. Poplar | — | — | 55,120 | 55,120 |
| | 233,855 | 1,184,494 | 1,130,644 | 2,548,993 |
| 81. Kilburn | — | 10,000 | — | 10,000 |
| 82. Hornsey | 22,474 | 14,587 | — | 37,061 |
| | 256,329 | 1,209,081 | 1,130,644 | 2,596,054 |

POPULATION of the DISTRICTS drained on the SOUTH SIDE of the THAMES in 1881.

| District. | Population draining into | | | Population not drained. | Total Population in 1881. |
|---|---|---|---|---|---|
| | High Level. | Low Level. | Outfall. | | |
| 52. Southwark | — | 28,628 | — | — | 28,628 |
| 53. Kent Road | — | 21,383 | — | — | 21,383 |
| 54. Newington | — | 145,100 | — | — | 145,100 |
| 55. St. Olave | — | 3,047 | — | — | 3,047 |
| 56. Bermondsey | — | 95,529 | — | — | 95,529 |
| 57. Rotherhithe | — | 36,010 | — | — | 36,010 |
| 58. Waterloo Road | — | 31,517 | — | — | 31.517 |
| 59. Lambeth | — | 59,698 | — | — | 59,698 |
| 60. Kennington | 3,220 | 77,300 | — | — | 80.520 |
| 61. Brixton | 60,830 | 1,987 | — | — | 62.817 |
| 62. Norwood | 19.017 | — | — | — | 19,017 |
| 63. Clapham | 24,250 | 12,128 | — | — | 36,378 |
| 64. Battersea | 2,150 | 105,098 | — | — | 107.248 |
| 65. Wandsworth | — | 28,005 | — | — | 28,005 |
| 66. Putney | — | 13,071 | — | 150 | 13,221 |
| 67. Streatham | 19,160 | 6,385 | — | — | 25,545 |
| 68. Dulwich | 5,590 | — | — | — | 5,590 |
| 69. Camberwell | 39,400 | 19,690 | — | — | 59,090 |
| 70. Peckham | 46,700 | 24,365 | — | — | 71,065 |
| 71. St. George | — | 50,810 | — | — | 50,810 |
| 72. Deptford | 16,930 | 67,711 | — | — | 84,641 |
| 73. Greenwich | — | 30,323 | 16,300 | — | 46,623 |
| 74. Eltham | 5,227 | — | — | 600 | 5,827 |
| 75. Lee | 18,708 | — | — | 2,850 | 21,558 |
| 76. Lewisham | 17,859 | — | — | 2,000 | 19,859 |
| 77. Sydenham | 25,070 | — | — | 1,000 | 26,070 |
| 78. Charlton | 870 | — | 9,860 | 200 | 10,930 |
| 79. Woolwich | — | — | 36,600 | — | 36,600 |
| 80. Plumstead | — | — | 31,652 | 1,600 | 33,252 |
| | 304,981 | 857,785 | 94,412 | 8,400 | 1,265,578 |
| 80*a*. Penge | 18,870 | — | — | — | 18,870 |
| 83. } Croydon 84. } | 8,000 | — | — | — | 8,000 |
| | 331,851 | 857,785 | 94,412 | 8,400 | 1,292,448 |
| | | | | | 8,400 |
| | | | | | 1,284,048 |

In Table 4 we have the population in each of those districts, and the quantity of sewage which would be given off by each of those districts.

*Table No. 4 was handed in, and was as follows:—*

QUANTITY of SEWAGE intercepted at various points by the SEWERS on the NORTH SIDE of the THAMES, and the TIME occupied by the SEWAGE in travelling to BARKING.

| Point of Interception. | Population draining at point of interception. | Amount of Sewage intercepted in 24 Hours. | Time occupied by Sewage in travelling from point of interception to Barking. |
|---|---|---|---|
| *High Level Sewer.* | | | H. M. |
| 1. Southampton Road | 22,718 | 113,590 | 3 36 |
| 2. Maiden Lane | 21,847 | 109,235 | 3 28 |
| 3. Holloway Road | 30,343 | 151,715 | 3 21 |
| 4. Great Northern Railway. | 40,314 | 201,570 | 3 11 |
| 5. Green Lanes | 22,474 | 112,370 | 3 3 |
| 6. Manor Road | 5,695 | 28,475 | 2 53 |
| 7. Hackney Brook | 8,074 | 40,370 | 2 50 |
| 8. Dalston Lane | 18,800 | 94,000 | 2 36 |
| 9. Church Street, Hackney. | 34,599 | 172,995 | 2 32 |
| 10. Wick Lane | 33,896 | 169,480 | 2 17 |
| 11. Junction with Mid. Level S. | 17,569 | 87,845 | 2 7 |
| | 256,329 | 1,281,645 | |
| *Middle Level Sewer.* | | | |
| 12. Cornwall Road | 12,643 | 63,215 | 6 25 |
| 13. Uxbridge Road | 50,849 | 254,245 | 6 1 |
| 14. Grand Junction Road | 88,578 | 442,890 | 5 33 |
| 15. James Street | 88,471 | 443,705 | 4 59 |
| 16. Regent Street | 94,298 | 471,490 | 4 50 |
| 17. Wells Street | 13,864 | 69,320 | 4 43 |
| 18. Bloomsbury Street | 94,174 | 470,870 | 4 30 |
| 19. Bedford Row | 11 950 | 59,750 | 4 14 |
| 20. Fleet Sewer | 236,991 | 1,184,955 | 4 1 |
| 21. Goswell Street | 32,784 | 163,920 | 3 49 |
| 22. City Road | 31,232 | 156,160 | 3 34 |
| 23. Tabernacle Square | 230,097 | 1.150,485 | 3 28 |
| 24. High Street, Shoreditch. | 84,354 | 421,770 | 3 18 |
| 25. Cambridge Road | 52,709 | 263,545 | 2 48 |
| 26. Regent's Canal | 20,628 | 103,140 | 2 30 |
| 27. Junction with High Level Sewer. | 18,530 | 92,650 | 2 7 |
| | 1,162,422 | 5,812,110 | |
| *Piccadilly Branch.* | | | |
| 28. King's Road | 13,653 | 68,265 | 5 43 |
| 29. | 16,415 | 82,075 | 5 10 |
| 30. | 16,591 | 82,955 | 4 50 |
| | 46,659 | 233,295 | |
| *Low Level Sewer.* | | | |
| 31. Stamford Brook | 35,928 | 179,640 | 9 5 |
| 32. Brook Green | 46,682 | 233,410 | 8 38 |
| 33. Fulham Road | 8,559 | 42,795 | 7 35 |
| 34. Fulham Branch | 32,171 | 160,855 | 7 20 |
| 35. Eel Brook | 6,951 | 34,755 | 7 9 |
| 36. Counter's Creek | 136,330 | 681,650 | 7 4 |
| 37. Church Street | 46,483 | 232,415 | 6 48 |
| 38. Smith Street | 46,218 | 231,090 | 6 27 |
| 39. Ranelagh | 54,793 | 273,965 | 6 20 |
| 40. King's Scholars Pond | 38,691 | 193,455 | 5 52 |
| 41. Horseferry Road | 35,482 | 177,410 | 5 31 |
| 42. Northumberland Street | 42,501 | 212,505 | 5 7 |
| 43. Savoy | 8,034 | 40,170 | 4 59 |
| 44. Fleet | 49,119 | 245,595 | 4 40 |
| 45. London Bridge | 57,168 | 285,840 | 4 17 |
| 46. Tower Hill | 7,185 | 35,925 | 4 0 |
| 47. Dock Street | 63,237 | 316,185 | 3 47 |
| 48. Cannon Street Road | 81,479 | 407,395 | 3 36 |
| 49. Devonport Street | 99,443 | 497,215 | 3 19 |
| 50. Cotton Street | 107,504 | 537,520 | 2 49 |
| 51. Brickfield Lane | 12.971 | 64,855 | 2 22 |
| | 1,016,929 | 5,084,645 | |
| *Hackney Wick Branch.* | | | |
| 52. | 21,810 | 109,050 | 3 7 |
| 53. Junction with Low Level Sewer. | 91,905 | 459,525 | 2 16 |
| | 113,715 | 568,575 | |

13,651. (*Chairman.*) Would you give us your results upon your own authority. Of course you can be cross-examined if the other side does not agree with you?—I am giving you the results, but I am only now going through these to show the principle upon which these tables have been calculated. The importance of the point is this: owing to the largeness of the district, the sewage from these different districts arrives at the terminus at Barking at very different times, and you will see, by the diagram which I shall put before you, that it is that which really answers the question.

(*Chairman.*) You had better do it your own way. I never found that I could save any time by endeavouring to cut matters short, but I do not mind telling you that, as far as I am concerned, there really, to my mind, has not been a substantial complaint established of the condition of the water above Greenwich. I do not mean to say that sewage has not been traced to be there, but what then? It is not a grievance of which anybody has made a loud complaint, or a complaint which you would be justified in going to an expenditure of millions to remedy.

(*Witness.*) Adding to that, that no plan you could adopt would prevent the necessity of having recourse to overflows at times.

13,652. (*Chairman.*) I suppose, if you trebled the sewers at a cost of about ten or it might be twenty millions of money, they would run over much less frequently than they do now?—No doubt, but it would be practically impossible to make those gigantic sewers.

(*Chairman.*) What has struck me is that there has been really no substantial complaint as to the condition of the river above Greenwich; there is no one who comes forward and says that there is.

(*Witness.*) No; but, as the evidence stands upon the notes now, it might lead you to believe that an essential part of any outlay would be for such a material alteration of the sewers within the metropolis as would prevent the overflows overflowing so frequently.

(*Mr. Norman Bazalgette.*) The way it stands now against the Metropolitan Board is that the discharge of the storm overflows above Greenwich has contributed to the fouling of the river below Greenwich.

(*Chairman.*) So it has, theoretically; no one can say anything more; but it would be a wonderful thing if it should be innocuous between Hammersmith and Greenwich, and should suddenly break out in a noxious form below. But still it is impossible for us to refuse to receive such evidence as you are now tendering, because we must consider the case upon all the evidence; and it may be that the learned counsel—for the prosecution I was going to say,—or my learned brethren, might consider that there was a grievance; so we must hear it.

(*Witness.*) The result, therefore, of this Table No. 4 is to show the amount of sewage which is afforded in 24 hours by each of the districts coloured upon the plan; and I show in the last column the intervals of time which elapse between the sewage from each of those districts entering the sewer and the time it arrives at the outfall at Barking. In order to determine the hour at which the maximum flow from each branch sewer will come down into the intercepting sewer, by which I mean the Board's Sewer, I have adopted the gaugings which were taken by Mr. John Taylor for the Referees to whom the Metropolitan Drainage Scheme was referred by the First Commissioner of Works previous to the construction of those works; because those experiments extended over some three or four months, and were taken with very great exactness. In this Report on Metropolitan Drainage of 1857, which I believe is in the hands of the Commission, will be found extremely elaborate tables taken every hour, and in some cases every quarter of an hour, giving the flow of the sewers; and a table is also given of the dry-weather flow. From that table I have prepared a diagram, which is now in your Lordship's hands, and you will see that the hours are beneath; that the sewage is at the minimum at 4 o'clock in the morning; then it rises up to its maximum at 10 in the morning; then it falls until 3 o'clock and rises again in the afternoon, and falls down towards midnight. That has been the basis that I have taken for the discharge of the sewage from the branch sewers into the Board's main intercepting sewer (*handing in a diagram*, No. 23, Appendix AO). I have then been able to arrive at the amount of sewage that would actually be discharged at each hour at Barking, which is of course the result we want to obtain, and it is an important question.

13,653. (*Chairman.*) This diagram is taken from the figures of 1857, but are the same sewers in existence now?—Yes; that represents a branch sewer, and the behaviour of the branch sewers is very much the same now as it was then. In Diagram No. 24, Appendix AP, the vertical height between the line AA and the line BB is equal to the total discharging capacity of the outfall sewer at Barking, viz., 34,764 cubic feet per minute. The portion of the diagram coloured red shows at each hour how much of that discharging capacity would really be occupied in carrying away the sewage at that particular hour; and therefore your Lordship will see that the maximum flow in the outfall sewer upon the northern side is at half-past two, when it amounts to about 15,000 cubic feet per minute. Diagram No. 33 Appendix AQ, gives a section of the High, Low, and Middle Level Sewers upon the northern side, and shows the height to which those respective sewers would be filled by the maximum flow of the sewage at the present time, that is to say, the dry-weather flow. Your Lordship will therefore see that in the High Level Sewer, which from the plan, you see, serves an area which is only partially built over, a very large provision has been made for future increase and for rainfall. The maximum flow in the High Level Sewer takes place at half-past one; the maximum flow in the Middle Level Sewer takes place at half-past two, and amounts to 7,788 cubic feet per minute; whereas the total discharging capacity is 16,620 cubic feet; and of the Low Level Sewer the maximum discharge takes place at 4.30, the discharge then being 6,570 cubic feet per minute, whereas the total discharging capacity is 14,524 cubic feet.

13,654. Do you take the end of the sewer to be the point of discharge?—Yes; the lowest point above their being united into the three sewers below; the three sewers below represent the three outfall sewers which carry the sewage from Abbey Mills to Barking Reservoir.

13,655. Are they the same size all the way through?—The outfall sewers are; the other sewers are graduated, commencing at from three to four feet in diameter, being graduated according to the work they will ultimately have to do, by which a great saving of expense was effected. Your Lordship will see the combined sewage of the three sewers fills the outfall sewer to a height of four feet, and leaves the carrying capacity shown upon the section No. 24 by the blank space above the red colour. So far with regard to sewage. Now I come to the rainfall. I have prepared a plan, No. 22, which shows also the proportion of each district, the rainfall of which has to be carried off by the sewers respectively.

13,656. Putting it very shortly, is what you say this: that the capacity, leaving out rainfall, is double the quantity they are now called upon to discharge at their maximum amount of flow?—Very much more.

13,657. I know that the High Level Sewer is very much more?—And the others also.

13,658. In dry weather, I am saying?—The High Level nine times, the Middle Level more than twice, the Low Level more than twice, the outfall sewers much more than twice. Now, with regard to rainfall. In the

*Mr. H. Law. M. Inst. C.E.*

29 May 1883.

same way I have a table, No. 5, showing Registration London, Metropolitan London, and Drained London, and I need only trouble your Lordship with these figures. Registration London contains 78,080 acres, of that number 3,361 acres consist of the River Thames or canals or other water, which, of course, must be excluded. Metropolitan London, without the water, contains 74,547 acres, but Drained London (without the water, of course) contains 65,001 acres, of which 32,158 are upon the northern side of the Thames and 32,843 upon the southern side.

*Table No. 5 was handed in, and was as follows :—*

AREA OF THE METROPOLIS.

| | Acres. | |
|---|---|---|
| Registration London :— | | |
| Land - - - - | 74,419 | |
| Water - - - - | 3,661 | |
| Total - - - | 78,080 | |
| Metropolitan London :— | | |
| Registration London, as above - - | 74,419 | |
| Add Penge - - - | 770 | |
| | 75,189 | |
| Deduct Mottingham - - | 642 | |
| Land - - - - | 74,547 | |
| Water - - - - | 3,661 | |
| Total - - - | 78,208 | |
| Metropolitan London, land only :— | | |
| North of the Thames, without North Woolwich - - - - | 30,904 | |
| Add North Woolwich - - | 414 | |
| Total Metropolitan London, North - - - | 31,318 | |
| | Acres. | |
| South of the Thames | 43,515 | |
| Add Penge - - | 770 | |
| | 44,285 | |
| Acres. | | |
| Deduct Mottingham 642 | | |
| „ North Woolwich - 414 | | |
| | 1,056 | |
| Total Metropolitan London, South - | 43,229 | |
| | 43,229 | |
| | 74,54 | |
| Drained London :— | | |
| Metropolitan London, North - | 31,318 | |
| Not drained - - | 929 | |
| | 30,389 | |
| Add Kilburn - - | 858 | |
| „ Hornsey - - | 911 | |
| Total Drained London, North - - | 32,158 | |
| | | 32,158 |
| Metropolitan London, South - | 43,229 | |
| Not drained - - | 11,216 | |
| | 32,013 | |
| Add Upper Norwood - | 268 | |
| „ Penge - - | 562 | |
| Total Drained London, South - - | 32,843 | |
| | | 32,843 |
| Total Drained London - | | 65,001 |

65,001 acres, equal to 101·56 square miles.

Here I might just incidentally mention that we have an explanation of the difference in the quantity of sewage per person upon the two sides of the river, because, while we have a very much larger population upon the northern side than we have upon the southern side, on the southern side we have to provide for an equal area of general drainage, such as the rainfall from the roofs of houses and the leakage from house drains, and imperfectly formed drains entirely beyond the control of the Board of Works, which are really inevitable and cannot be excluded. I may say the total acreage drained is 65,000 acres, which is equal to 101·56 square miles ; that is really the area in square miles which is drained. In order to arrive at the hours in which the rainfall will arrive at Barking, I have divided the areas amongst the several sewers precisely upon the same principle as I did the people ; and, in order to determine how much of the rainfall would be delivered into the sewers, I have made this assumption, which is really going upon the same lines as were suggested by the Referees in their Report of 1857. I have made this assumption, that wherever the population exceeded 80 persons to the acre,—and in some of the districts, as shown in the table, there are 300 persons to the acre,—but wherever the population was in excess or reached 80, I have taken the whole of the rainfall as going into the sewer. I have made the quantity of rain falling and actually reaching the sewers proportionate to the population, so that, if there were 40 persons to the acre, half the rain would go into the sewers ; and that is a very rational mode of doing it, because the density of population expresses very nearly the comparative proportion occupied by gardens and by houses, and for other purposes.

13,659. What you mean is that, if it is a sparse population, it falls upon the ground and gets absorbed; that is your supposition ?—That is so.

*Tables 6 and 7 were handed in, and were as follows :—*

AREAS of the DISTRICTS DRAINED on the NORTH SIDE of the THAMES, showing also the DENSITY of POPULATION and the RAINFALL discharged.

| Reference No. to Plan L. & C., No. 22. | District. | Area draining into | | | Area not drained by Metropolitan System. | Total Area. | Population. | No. of Persons to an Acre. | Cubic feet per min. per acre for 0·01" rain per hour. | Rain discharged in cubic feet per min. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | High Level Sewer. | Middle Level Sewer. | Low Level Sewer. | | | | | | High Level Sewer. | Middle Level Sewer. | Low Level Sewer. |
| | | Acres. | Acres. | Acres. | Acres. | Acres. | | | | | | |
| 1 | St. Mary, Paddington | — | 791 | — | — | 791 | 69,785 | 88·22 | ·605 | — | 478·6 | — |
| 2 | St. John, Paddington | — | 441 | — | — | 441 | 37,313 | 84·60 | ·605 | — | 266·8 | — |
| 3 | Kensington Town | — | 170 | 1,323 | — | 1,493 | 120,127 | 80·44 | ·605 | — | 102·9 | 800·4 |
| 4 | Brompton | — | — | 693 | — | 693 | 42,797 | 61·76 | ·467 | — | — | 323·7 |
| 5 | Hammersmith | — | — | 2,280 | — | 2,280 | 71,916 | 31·55 | ·239 | — | — | 543·9 |
| 6 | Fulham | — | — | 1,716 | — | 1,716 | 42,895 | 25·00 | ·189 | — | — | 324·5 |
| 7 | Chelsea | — | 144 | 649 | — | 793 | 88,101 | 111·10 | ·605 | — | 87·1 | 392·6 |
| 8 | Hanover Square | — | 233 | 322 | — | 555 | 30,339 | 54·67 | ·413 | — | 96·2 | 133·0 |
| 9 | Belgrave | — | — | 543 | — | 543 | 59,178 | 109·00 | ·605 | — | — | 328·5 |
| 10 | St. John, Westminster | — | — | 211 | — | 211 | 35,482 | 168·20 | ·605 | — | — | 127·7 |
| 11 | St. Margaret, Westminster | — | — | 586 | — | 586 | 24,604 | 42·00 | ·318 | — | — | 186·3 |
| 12 | St. James, Westminster | — | 94 | 68 | — | 162 | 29,865 | 184·40 | ·605 | — | 56·9 | 41·1 |
| 13 | St. Ann's, Soho | — | 50 | 4 | — | 54 | 16,591 | 307·20 | ·605 | — | 30·3 | 2·4 |
| 14 | St. Mary, Marylebone | — | 448 | — | — | 448 | 87,673 | 195·70 | ·605 | — | 271·0 | — |
| 15 | Christchurch, Marylebone | — | 508 | — | — | 508 | 33,691 | 66·32 | ·501 | — | 254·5 | — |
| 16 | St. John, Marylebone | — | 543 | — | — | 543 | 33,640 | 61·95 | ·469 | — | 254·4 | — |
| 17 | Hampstead | 606 | 1,642 | — | — | 2,248 | 45,436 | 20·21 | ·153 | 92·7 | 251·2 | — |
| 18 | Regent's Park | — | 410 | — | — | 410 | 39,103 | 95·37 | ·605 | — | 248·1 | — |
| 19 | Tottenham Court | — | 144 | — | — | 144 | 27,728 | 192·50 | ·605 | — | 87·1 | — |
| 20 | Gray's Inn Lane | — | 154 | — | — | 154 | 30,229 | 196·30 | ·605 | — | 93·2 | — |
| 21 | Somers Town | — | 183 | — | — | 183 | 34,355 | 187·80 | ·605 | — | 110·7 | — |
| 22 | Camden Town | — | 165 | — | — | 165 | 17,406 | 105·50 | ·605 | — | 99·8 | — |
| 23 | Kentish Town | 754 | 843 | — | — | 1,597 | 87,388 | 54·72 | ·414 | 312·0 | 348·8 | — |
| 24 | Islington, West | 698 | 524 | — | — | 1,222 | 121,374 | 99·35 | ·605 | 422·3 | 317·0 | — |
| 25 | „ East | 1,185 | 685 | — | — | 1,870 | 161,254 | 82·37 | ·605 | 716·9 | 414·4 | — |
| 26 | Stoke Newington | 432 | 157 | — | — | 589 | 22,780 | 38·68 | ·293 | 126·6 | 6·0 | — |
| 27 | Stamford Hill | 313 | 36 | 251 | — | 600 | 9,256 | 15·43 | ·117 | 36·6 | 4·2 | 29·4 |
| 28 | West Hackney | 213 | 253 | — | — | 466 | 37,600 | 80·69 | ·605 | 128·9 | 153·1 | — |
| 29 | Hackney | 611 | 49 | 760 | 340 | 1,760 | 76,886 | 43·69 | ·330 | 201·6 | 16·2 | 250·8 |
| 30 | South Hackney | 309 | — | 110 | — | 419 | 39,878 | 95·18 | ·605 | 186·9 | — | 66·6 |
| 31 | St. Giles | — | 245 | — | — | 245 | 45,257 | 184·70 | ·605 | — | 148·2 | — |
| 32 | St. Martin-in-the-Fields | — | 16 | 270 | — | 286 | 17,447 | 61·01 | ·461 | — | 7·4 | 124·5 |
| 33 | Strand | — | — | 117 | — | 117 | 16,067 | 137·40 | ·605 | — | — | 70·8 |
| 34 | St. George and St. Andrew | — | 90 | 107 | — | 197 | 35,850 | 182·00 | ·605 | — | 54·5 | 64·7 |
| 35 | Clerkenwell | — | 302 | 13 | 65 | 380 | 69,019 | 181·60 | ·605 | — | 182·7 | 7·9 |
| 36 | City Road | — | 160 | 75 | — | 235 | 46,847 | 199·30 | ·605 | — | 96·8 | 45·4 |
| 37 | St. Botolph | — | — | 83 | — | 83 | 11,168 | 134·60 | ·605 | — | — | 50·2 |
| 37*a* | Cripplegate | — | — | 66 | — | 66 | 7,185 | 108·80 | ·605 | — | — | 39·9 |
| 38 | London City | — | — | 388 | — | 388 | 19,218 | 49·54 | ·605 | — | — | 234·7 |
| 39 | St. Bride's | — | — | 131 | — | 131 | 13,735 | 104·90 | ·605 | — | — | 79·3 |
| 40 | Shoreditch | — | 73 | 68 | — | 141 | 22,333 | 158·40 | ·605 | — | 44·2 | 41·4 |
| 41 | Hoxton | — | 242 | — | — | 242 | 57,954 | 239·50 | ·605 | — | 146·4 | — |
| 42 | Haggerstone | — | 251 | — | — | 251 | 46,278 | 184·40 | ·605 | — | 151·9 | — |
| 43 | Hackney Road | — | 238 | 126 | — | 364 | 79,064 | 217·20 | ·605 | — | 144·0 | 76·2 |
| 44 | Bethnal Green | 140 | 162 | 72 | — | 374 | 47,942 | 128·10 | ·605 | 84·7 | 98·0 | 43·6 |
| 45 | Whitechapel | — | — | 372 | — | 372 | 71,350 | 191·80 | ·605 | — | — | 225·1 |
| 46 | St. George-in-the-East | — | — | 213 | — | 213 | 47,011 | 220·70 | ·605 | — | — | 128·9 |
| 47 | Limehouse | — | — | 421 | — | 421 | 58,500 | 138·90 | ·605 | — | — | 254·7 |
| 48 | Mile End | — | — | 673 | — | 673 | 105,573 | 156·90 | ·605 | — | — | 407·2 |
| 49 | Bow | 45 | 100 | 271 | 110 | 526 | 37,060 | 70·46 | ·533 | 24·0 | 53·3 | 144·4 |
| 50 | Bromley | — | — | 587 | — | 587 | 64,345 | 109·60 | ·605 | — | — | 55·1 |
| 51 | Poplar | — | — | 968 | — | 968 | 55,120 | 56·90 | ·430 | — | — | 416·2 |
| | | 5,306 | 10,546 | 14,537 | 515 | 30,904 | | | | | | |
| 81 | Kilburn | — | 858 | — | — | 858 | 10,000 | 11·65 | ·088 | — | 75·5 | — |
| 82 | Hornsey | 674 | — | — | — | 674 | 37,061 | 33·30 | ·252 | 169·8 | — | — |
| | South Hornsey | — | 237 | — | — | 237 | — | 61·60 | ·466 | — | 110·4 | — |
| | | 5,980 | 11,641 | 14,537 | 515 | 32,673 | | | | | | |
| | | | | | | 515 | | | | | | |
| | Total Area drained = | | | 50·225 sq. miles = | | 32,158 | | | | | | |

*Mr. H. Law. M. Inst. C.E.*

29 May 1883.

AREAS of the DISTRICTS drained on the SOUTH SIDE of the THAMES.

| Reference No. to Plan L. & C., No. 23. | District. | Area draining into | | | Area not draining into Metropolitan System. | Total Acreage. |
|---|---|---|---|---|---|---|
| | | High Level Sewers. | Low Level Sewers. | Outfall Sewer. | | |
| | | Acres. | Acres. | Acres. | Acres. | |
| 52 | Southwark | — | 203 | — | — | 203 |
| 53 | Kent Road | — | 103 | — | — | 103 |
| 54 | Newington | — | 813 | — | — | 813 |
| 55 | St. Olave | — | 55 | — | — | 55 |
| 56 | Bermondsey | — | 695 | — | — | 695 |
| 57 | Rotherhithe | — | 578 | — | — | 578 |
| 58 | Waterloo Road | — | 167 | — | — | 167 |
| 59 | Lambeth | — | 348 | — | — | 348 |
| 60 | Kennington | 40 | 948 | — | — | 988 |
| 61 | Brixton | 1,406 | 23 | — | — | 1,429 |
| 62 | Norwood | 1,009 | — | — | — | 1,009 |
| 63 | Clapham | 737 | 400 | — | — | 1,137 |
| 64 | Battersea | 21 | 2,182 | — | — | 2,203 |
| 65 | Wandsworth | — | 2,405 | — | — | 2,405 |
| 66 | Putney | — | 1,380 | — | 835 | 2,215 |
| 67 | Streatham | 2,455 | 870 | — | 140 | 3,465 |
| 68 | Dulwich | 1,450 | — | — | — | 1,450 |
| 69 | Camberwell | 285 | 1,093 | — | — | 1,378 |
| 70 | Peckham | 775 | 400 | — | — | 1,175 |
| 71 | St. George | — | 447 | — | — | 447 |
| 72 | Deptford | 720 | 962 | — | — | 1,682 |
| 73 | Greenwich | — | 569 | 785 | 380 | 1,734 |
| 74 | Eltham | 330 | — | — | 4,087 | 4,417 |
| 75 | Lee | 458 | — | — | 1,142 | 1,600 |
| 76 | Lewisham | 1,639 | — | — | 2,105 | 3,744 |
| 77 | Sydenham | 1,543 | — | — | 73 | 1,616 |
| 78 | Charlton | 214 | — | 1,675 | 90 | 1,979 |
| 79 | Woolwich | — | — | 699 | 414 | 1,113 |
| 80 | Plumstead | — | — | 1,417 | 1,950 | 3,367 |
| | | 13,082 | 14,641 | 4,576 | 11,216 | 43,515 |
| 80a | Penge | 770 | — | — | — | 770 |
| | | 13,852 | — | — | — | 44,285 |
| | *Deduct*— Mottingham - 642 | — | — | — | — | — |
| | Woolwich - 414 | — | — | — | — | 1,056 |
| | | | | | | 43,229 |
| 3 | Upper Norwood | 268 | — | — | — | 268 |
| 84 | Penge | 562 | — | — | — | 562 |
| | | 14,682 | — | — | — | 44,059 |
| | Area not drained | — | — | — | — | 11,216 |
| | | | | | | 32,843 |

13,660. If it is a dense population, it falls either upon roofs or upon the paved streets?—That is so, and it finds its way to the sewers.

13,661. That is your proposition?—That is so, and that enables me to determine the quantity. Then, to enable me to determine the time, I have assumed that, if rain falls at any given spot, for instance, at Hampstead, the time which it would take to traverse the local sewers before it reaches the great sewer would be 180 feet to a minute, which is, I think, a fair and proper velocity to give. The diagram I have placed before you contains figures showing the hours the sewage will occupy in traversing the sewer before it reaches Barking, assuming the sewer to be running half full. I have desired really to make an investigation which should not be open to any question; and, therefore, I have taken the velocity as that due to the sewer when either half or quite full; whereas, under ordinary circumstances, the sewers are not nearly half filled, and the velocities are consequently not so great; but I wish it to be taken upon such principles as I think cannot be questioned. The result of the calculations so based is shown upon diagram No. 25 (*handing in the same, see Appendix* A k). I have assumed in this diagram that the rain commences to fall at the same time all over London, and falls at the rate of a quarter of an inch every 24 hours continuously without cessation for any period which you please. It will be then 2 hours and 20 minutes before the first rain reaches Barking, as shown by this diagram, because the outfall sewers are not sewers of reception, but merely of conveyance; they receive nothing after Abbey Mills; therefore, the first rain which falls, which will be that of the district of Bow, will take 2 hours and 20 minutes, or thereabouts, before it reaches the outfall, and this diagram shows you the successive increments of rain in the sewer until it has attained its full quantity, which would be delivered for ever if the rain continued at that rate.

13,662. (*Sir John Coode.*) This diagram reads from right to left, does it not?—Yes, it shows the intervals of time; the figures at the bottom are intervals of time before any given quantity will arrive. If we take the figure 6 and apply to it a scale, we shall see that it there measures about 10,500, and that means that it will be six hours after the rain has commenced to fall before the quantity being discharged at Barking will have amounted to 10,500 cubic feet per minute.

13,663. (*Mr. Beaumont Morice.*) You begin at the 2 hours and 30 minutes; that is the time before the first rain reaches Barking?—That is so.

13,664. (*Sir John Coode.*) The 0 is at Abbey Mills?—Yes, the 0 is at Abbey Mills.

13,665. And the rain entering at Abbey Mills takes 2½ hours to flow from Abbey Mills to Barking?—That is so. Now, if you apply the maximum rainfall to the maximum of sewage, you will still see a discharging capacity of 6,000 cubic feet per minute left in the sewer; so that is a very different state of things to that alleged by Mr. Latham.

13,666. (*Chairman.*) But I do not see that at present?—Applying the height of the blue to the height of the red, you can see how far it exhausts the discharging capacity.

13,667. Is that what you mean it for?—It is what I mean. I have made two separate diagrams in order that you may superpose the red at any part you like.

13,668. Suppose it rains for a week with a steady rain at the rate of a quarter of an inch per diem?—Then the quantity of rain coming off the ground would amount to 14,000 cubic feet per minute.

13,669. But I do not understand the use of the hour in the diagram, because, if it continues, I will put it for a week, as an extreme case, then you would have an equable flow all the way along, would you not?—You would have an equable flow all the way along, and what you would have to do would be this: having taken the height by your compasses, to see how much of your sewer would be occupied at any hour of any day, you would merely have to apply it upon the top of the red, and you would then see that, even when the maximum of sewage was flowing, your sewer would be only discharging that amount.

13,670. It would be more plain to an uneducated mind like mine if you put it in this way; how much of the sewer would that rain occupy, supposing there were no sewage flowing at all?—The rainfall alone without any sewage would occupy the proportion of the sewer shown upon the extreme left hand of the diagram No. 25, there would then be a parallel line all the way along. When the rain became continuous the line would become a uniform line, that will be the quantity of rainfall which came off the ground.

13,671. (*Sir John Coode.*) Assuming that it is not

an excess of a quarter of an inch in 24 hours?—Yes.

13,672. (*Professor Williamson.*) But is that in accordance with the fact; does it not sometimes rain in more than that proportion to the hour?—It certainly does, but I am coming to that point directly. What I have done is this, I have taken a quarter of an inch, because that is what the system is designed to carry, as Sir Joseph has told you. Therefore I want to show that the system is capable of doing that, and that a margin is left for an increase of population and of sewage.

13,673. (*Chairman.*) I think I understand generally what you mean, but still I think your diagram is a little too ingenious for me. What I understand you to say is that the sewer would carry off a continuous rainfall for a week of a quarter of an inch per diem, together with the maximum amount of sewage at any time?—Yes, that is so.

13,674. (*Professor Williamson.*) If it rained uniformly for 24 hours, but not otherwise?—That I am coming to; you have a surplus discharging capacity of between 5,000 and 6,000 cubic feet a minute.

13,675. (*Chairman.*) I do not quite see what the use of this blue diagram is, I understand perfectly how you apply it?—The use of this diagram, my Lord, is this. I think it is really necessary that I should now refer you to an answer.

13,676. I remember very well what Sir Joseph Bazalgette said, if that is what you are thinking of. Sir Joseph Bazalgette told us that he thought when he was designing the sewers, unless I am doing him an injustice, that when the sewage began to run there would be some time of the day at which it would be at its maximum, that it would be at its maximum at one spot, but that he found out that, in consequence of some of the supplies of sewage being nearer to the outfall than the rest, the distribution of the flow was more even than he had expected to find that it would be?—That is what the pink diagram shows. It is very remarkable how uniform the flow is until nine at night, but of course that arises from the fact that the sewage which comes from Chiswick takes nine and a half hours to reach the outfall, whereas that which comes from Bow only takes two and a half hours. But Mr. Baldwin Latham stated in his evidence that whenever it rained the storm overflows came into action at some part or other of the river. It was a most important statement, and one which it was only right fully to investigate, because, if it were so, some remedy would be absolutely necessary.

13,677. Mr. Baldwin Latham could not have said that whenever it rained in any quantity, no matter how small the quantity, the storm overflows came into operation?—It is so stated, it is upon the notes.

(*Chairman.*) I may put it hypothetically. If Mr. Baldwin Latham did say that, I should not believe Mr. Baldwin Latham.

(*Mr. Baldwin Latham.*) I should not have expected you to believe me.

(*Witness.*) It is upon the notes.

13,678. (*Sir John Coode.*) It must have been a misapprehension, or else explained elsewhere?—I am very glad that that is removed. I may further call your attention to this fact, that I have gone a little carefully into this matter of rain, because you have also a report which Dr. Frankland put in, in which Dr. Frankland assumes that of the whole quantity of rain which falls upon the whole of London, including the River Thames and the canals, however slight the shower, four-fifths falls into the sewers, and upon that very elaborate tables have been put in to show the quantity of detritus which is brought by the sewer and delivered and discharged into the Thames, so that it is a very important question.

13,679. (*Professor Williamson.*) Does Dr. Frankland say that there is always that proportion, or that that is the average proportion?—He says in this table, "The rain is calculated as falling upon 122 square "miles," the absolute area is only 102 square miles, and that of course contains an enormous quantity of vacant land, parks and squares, and places from which the rain cannot find its way to the sewers. "And "20 per cent. is allowed for evaporation, which is "probably much in excess of the truth;" he assumes that the whole of the rest falls into the sewers.

13,680. That must be the average?—No, each case. For instance, when only two-tenths of an inch fall, he has multiplied out the quantity of detritus (from what I think were imperfect data) which were supposed to be in the sewage with that quantity of rain, and has taken that as being discharged from the sewer into the river at Barking.

13,681. (*Chairman.*) I wonder whether Dr. Frankland ever knew this, I happen to have two cottages in the country, one covered with tiles and one covered with slates, and there are rain water tanks to both cottages, and the slate man, if he has the least shower of rain, gets rain in his tanks, but the tile man does not get a drop?—That is so. If you see a summer shower fall, it wets the pavement, but does not go into the sewer.

13,682. (*Sir John Coode.*) Was there no qualification in Dr. Frankland's statement?—So far from there being a qualification, he has reduced it to numerical results, and tables were put in to show them.

13,683. Under all conditions?—Under all conditions, however small the rain, and I shall of course have occasion to deal with that when I come to the discharge of the mud into the river, which is a very important point.

13,684. We shall hear your evidence, and shall see how that bears upon the table. I confess it did not strike me so.

13,685. (*Chairman.*) Have we no direct evidence from observation of the number of times the storm overflows have been seen to be in action?—Yes. Sir Joseph Bazalgette has given that to you, but you must bear this in mind, those observations could only be made at those stations where, from there being pumping or other operations going on, the Board have men to observe. Now at Question 7828 Mr. Baldwin Latham is asked, "Taking that district, how often "would the sewers be incapable upon the South "side?" To which he replied, "Upon the average "every time rain occurred the sewers must overflow "in the case of London."

13,686. I do not understand that "upon the average "every time"?—That is his answer. Then he is asked, "whenever it rained," to which he replied, "whenever it rained, at some point or other they "must overflow." I felt it desirable that that should be cleared up one way or another; it is very explicitly stated in the evidence. Now I wish to address myself to Professor Williamson's suggestion, which is a very important one, that of course this calculation of mine would be disturbed by a violent shower of rain; but this must be borne in mind. My diagram, No. 33, which shows the section of the sewers, shows how large an area remains unoccupied to be filled up by rain. The High Level Sewer, when the maximum flow of sewage is taking place, is only a seventh filled, and the vacant space which would be left available for rain would be 1,362,350 cubic feet before that sewer would become sufficiently filled to overflow by the storm overflows. The Middle Level Sewer would in the same way be capable of receiving with its maximum flow of sewage 1,115,290 cubic feet of rainfall before its overflows would come into operation, and the Low Level Sewer 1,675,623 cubic feet.

13,687. You mean for its whole length?—Yes, and the three outfall sewers, in the same way, 2,715,180 cubic feet, giving a total of 6,868,443 cubic feet, which is equal to eight hours' rainfall.

13,688. I do not quite understand you. You say the united capacity of the three main sewers and of the outfall sewers is so and so, what has that got to do with the storm overflows, because there is nothing overflows from the outfall sewer?—No, that is quite true, but that does not affect the question of the storm overflows; but the capacity of the three sewers, the

*Mr. H. Law, M. Inst. C.E.*

29 May 1883.

high, the middle, and the low level, must be filled before the storm overflows operate.

13,689. Do you mean there would be a sort of penning back?—Yes. If you recollect, Mr. Baldwin Latham stated that the joint discharging capacity of the three sewers was considerably in excess of that of the outfall sewer, which he said was a blot upon the plan.

13,690. Is it so?—No; this is the principle upon which they were proportioned. If you were to lay down for a moment the principle that each sewer should be capable of receiving all that the sewers coming into it would discharge, the principle being that the outfall sewer should carry all the three could bring down; then, if we come a little way further, and say the intercepting sewer must discharge all the branches can bring down; we should then be landed in this absurdity. There are 490,000 houses in London, each with a drain. Assuming each of those drains were only six inches diameter, and would discharge 40 cubic feet a minute, we should require, if the sewers in London were all discharging their maximum at once, 19,600,000 cubic feet, and we should require 1,680 sewers of that size to take away the sewage of London, instead of three.

13,691. The three intercepting sewers would not all be discharging at the same time?—That is so. The High Level having its greatest discharge at half past one, the Middle Level at half past two, and the Low Level at half past four, therefore the greatest economy was effected in proportioning the sewers to what they have to do. Before those sewers, the High, the Middle, and Low Level sewers, are united in the outfall, a storm overflow is provided in the River Lea, and similar storm overflows are provided, as indicated by Sir Joseph Bazalgette upon the plan, because it would have been practically impossible to have so designed the sewers as that they should have been competent to deal with the whole of the rainfall, which might under extraordinary circumstances have been delivered into them; but that is a very different thing from saying that whenever rain falls the storm overflows come into play.

13,692. As a matter of *a priori* calculation, have you come to any conclusion as to the number of times your storm overflows should come into operation?—I have not made that calculation; but the result of my calculation bears out the reasonableness of the return which has been furnished from observation. I would, in addition, say this, that these figures I have given you of the capacity of the sewers to be filled up by sudden falls of rain simply apply to the intercepting sewers themselves. I have calculated the capacity of the sewers of London, of which I have the dimensions; that would add two millions, and the sewers of the metropolitan district would be at least as much more, so that a very large number of hours would elapse before an overflow occurred, even after sudden rain. Now I have here an extract from a report which Mr. John Taylor made to the Referees as the result of his observations of the gaugings during heavy storms of rain. He says: "During the first four weeks of "the series of sewer gaugings, there was a "remarkable absence of rain, and, with the ex- "ception of the falls accompanying the storms "of June, there has scarcely been a sufficiently "decisive rain throughout the whole time to give any "very well defined results. An attentive considera- "tion, however, of the rainfall, with reference to the "gauging, evidently shows that no definite quantity "can be pronounced to flow off any given district, "with a given fall, so much depending on the "previous state of the ground, whether dried up or "saturated, on the season and amount of evapora- "tion, on the quantity of rain falling in a given time, "and on the long or short duration of the fall. In a "town district, such as that drained by the Savoy "and Northumberland Street sewers, it appears the "quantity running off into the sewers within six "hours after the fall of rain, varies from 10 to 60 per "cent. of the quantities fallen; while in a suburban "locality, such as the Counter's Creek sewer drains, "the quantity reaching the sewers would vary from "0 to 30 or 40 per cent. in 24 hours after the rain, "according to the previous conditions of the surfaces, "as above described, the remainder being carried off "by evaporation, absorption, and other causes." Then there is a footnote which is very valuable. "Of the "rain during the storm on the 20th June (nearly one "inch in 1¼ hour) 65 per cent. ran off this district "within 15 hours of the fall." It took 15 hours for the 65 per cent. to run off; 46 per cent. ran off in three-quarters of an hour after the rain ceased; 14 per cent. more in the next six and three-quarter hours, and 5 per cent. more in the next seven and a half hours, making the total of 65 per cent. Now I may mention that in the calculation I have made I admit of 70 per cent. running off. I am sure the calculation I have made is in excess of that which really happens. The result therefore is this, that, while the discharging capacity of the sewer is 34,764 cubic feet per minute, the maximum of the sewage will be 15,070, and the rainfall 14,242, leaving a surplus of 5,452 as the carrying capacity of the sewers, with the maximum sewage and rainfall.

13,693. (*Mr. Norman Bazalgette.*) That is to say, the margin which would be available for increase of population?—Yes. Now, I would wish to call your attention to Plan No. 22; you will see that certain districts are hatched round.

13,694. (*Sir John Coode.*) Are those discharging capacities which you have given to us the discharging capacities of the sewers when they reach the lip of the storm overflow; or do you assume the sewers to be absolutely full?—When they reach the lip of the storm overflow.

13,695. That will be their carrying capacity before the storm overflows have come into action?—Precisely so. Your Lordship will observe a certain district in the centre of London has hatched lines round it; that is the portion of London in which the population is now decreasing, and has been decreasing for several years. Out of the 80 districts into which I have divided London, you have 29 of those districts which have been for the last two censuses diminishing in their population and diminishing to this extent.

13,696. Each number represents a separate district?—Yes.

13,697. Does that apply to each of the 29 districts?—It is so. The figures are in the tables I have put in. In every one of those districts the population is diminishing; it contains 8,068 acres, or nearly one-ninth of the whole of the area under the Metropolitan Board of Works.

13,698. And what is the per-centage of diminution, taking it over the whole 29 districts?—In the city of London it is about a third of what it was 20 years ago.

13,699. But taking it over the whole of this hatched district?—I cannot give it at this moment but it is easily taken. Then I may mention that the adjoining districts show what has been called a decremental rate of increase, that is to say, that, although they increased very rapidly many years ago, that rate of increase as they attain their maximum is now becoming very slight, and after a few years they will have to be included in the shaded or hatched districts.

13,700. (*Professor Williamson.*) When you speak of diminution of population, you mean diminution in the number of people who sleep in the district?—Certainly. Then I would also point out another fact, which is this, that the future increase of London will be around its margin; it is diminishing in the centre; its population is spreading, consequently, the additional sewage which has to be brought in will be brought in at hours when the existing sewage is not running at its maximum; and that, again, makes a very important point when you are considering the size which should be given to the sewers. The principles upon which you would lay out the drainage for

a city of 117 square miles are very different indeed from those for a country town.

13,701. (*Chairman.*) If I cross Westminster Bridge, as I understand, I get into a district which you have marked as No. 58 ?—Yes.

13,702. Do you say the population is diminishing there ?—I say the population of Lambeth is diminishing, and I will give your Lordship the figures. I will put in the populations of all those districts; it will be a simple table.

13,703. Never mind that, unless they cross-examine you as to it. I will take it to be true. What inference do you draw from that ?—The inference I draw from that is that the population of London is spreading; that people now, who formerly lived in London, are enabled by the railways to live a little way out of London, so that the resident population of the denser portions is becoming less.

13,704. And what then ?

(*Professor Williamson.*) As regards sewage; that is the point ?—As regards sewage, of course the sewage round the margin of London is increased.

13,705. But does it diminish in the centre, that is the point ?—I have not referred to the day census of London, but I think the day census will be found pretty much the same.

13,706. (*Sir John Coode.*) Is there a day census ?—Yes, there is.

13,707. (*Chairman.*) How will all this affect our Report to Parliament with regard to the sewage of the metropolis ?—Very largely indeed, because, for instance, men do not take baths in the middle of the day, and the bath is one element and the largest element of the supply of water to the sewers.

13,708. (*Sir John Coode.*) What we want to arrive at is this: although the number sleeping within this particular district may be affected, how far is the sewage affected ?—I do not suggest, for a moment, a diminution of sewage, although I feel confident there is one.

13,709. You do not mean to convey to us that there is a diminution of sewage in anything like the ratio of population ?—No, but what I did mean was this: Mr. Baldwin Latham put in certain tables which assumed that the rate of increase of London was going on as it had done for some considerable time before, and I wish to show that not only is that ratio not going on so rapidly as it did, that it is what has been termed a decremental rate of increase; but I wish also to show that, as that increase takes place round the margin of London, that increase does not affect the sewer at the time when it is flowing at its maximum flow from the centre of London itself.

13,710. (*Chairman.*) There would be a more gradual flow from the sewers ?—Yes, the sewers would be filled at times when now they are not filled. I may mention also that, owing to some experiment now being made for a totally different purpose, one of the outfall sewers has been temporarily diverted from its use, the whole of the sewage being turned into the other two sewers, and that both the maximum time and the quantity of the sewage are singularly confirmatory of the conclusion which I have drawn here from these figures.

13,711. (*Sir John Coode.*) How long has it been that the two sewers are doing the work of three ?—The result is that they have been doing it with about 3 feet 9 of sewage in one and 4 feet of sewage in the other.

13,712. But how long have they been doing it ?—They have been doing it for about a month, and on Saturday, when it rained very heavily indeed, about 6 to 7 inches extra were gauged.

13,713. Was it gauged often on Saturday ?—It was not gauged, except by myself, for my own curiosity.

13,714. (*Chairman.*) Was the storm overflow at work ?—No, it could not have been, because the sewer was only running a little over 4 feet.

13,715. As I understand, if it rains very heavily at Chelsea, there might be an overflow at Chelsea, might there not, although the sewer were only half full ?—No, because you would have to fill up the Low Level Sewer.

13,716. Would you ? Because, as I understand, and that is certainly the case with the intercepting sewer, all the sewers are smaller the farther they are from the main outlet ?—They are, but proportionately to what they have to do at those places.

13,717. But what I said was, supposing a heavy shower at Chelsea, you might have at Chelsea an overflow, though, if there had been time for the water to get to the outfall, there would not have been an overflow ?—But, before an overflow can take place, you must have exhausted the carrying capacity of the sewers at Chelsea, and have filled up all the sewers; they would not begin to overflow until you had filled them; you must exhaust their carrying capacity, and also fill them; then they overflow, and not till then.

(*Sir John Coode.*) It would be what we call headed back.

13,718. (*Chairman.*) With great submission to you, I deny it. (*To the witness.*) Suppose you bored a hole in a tobacco pipe, and put some water in with very great pressure, the water would come out through that hole, though the bowl were not full, would it not ?—Yes, it might, but in this case the sewers are proportional to their work, and the water is not headed back; if it were headed back, the house drainage could not run into them.

(*Chairman.*) If I am wrong in this, let me be set right. Suppose the sewers at present in London to be of such a capacity that a shower of rain would fill them more quickly than they can discharge themselves, there would be an overflow there.

(*Sir John Coode.*) Yes, granting the premises, the conclusion is right.

(*Witness.*) Yes; but before you can do that, you have to fill the sewer up to the height at which the storm overflow is arranged to act, and, in doing that, you will have absorbed an enormous quantity of rain first to fill the sewer; and you will bear in mind that it is not stagnant water, but that it is flowing at very great speed, becoming greater as the sewer gets fuller.

13,719. (*Chairman.*) I know that, but I understand you to say that there could not be an overflow at Chelsea, because the outfall sewer was not full ?—If you so understand me, I did not express myself rightly.

13,720. (*Mr. Norman Bazalgette.*) Now, to go to another point. Will you tell us what your view is upon the question of the dilution of the sewage at the outfalls in the river ?—A very important part of this inquiry has been the percentage of sewage in the river, and I will address myself to that now; and, to avoid confusion of terms, I would say that we have to consider in the river the upland water, by which I understand the water which drains from the surface into the river, which finds its way by natural drainage into the river. Another kind of water which has not been spoken of, but is very important, is the spring water, which finds its way into the bed of the river through the springs; we have the sea water entering the Thames at the mouth; and the sewage; those four elements. Up to the present time you have heard nothing of the spring water; it has been quite ignored.

13,721. (*Sir John Coode.*) Can you show us cases of any perennial springs ?—Yes, I am now going to that question, and it is a very interesting one. I first of all wish to ascertain what it is reasonable that the river should deliver, comparing the upper and the lower. I therefore first ascertain the quantity of water which is abstracted by the water companies. I take the figures given by Mr. Baldwin Latham that the water supply was 16,090 cubic feet per minute, and I divide that according to the evidence given by Lieutenant-Colonel Bolton, who is the inspecting officer on behalf of the Local Government Board. The quantity abstracted from the Thames above Teddington Weir amounts to 7,778 cubic feet a minute, which must be added to the quantities gauged by Mr.

*Mr. H. Law, M. Inst. C.E.*

29 May 1883.

Baldwin Latham to ascertain what was the real discharge from the river; that is to say, what would have come over Teddington if the water companies had not abstracted it. In the same way, I add for the Lea 2,444 cubic feet per minute abstracted by the East London Waterworks, and I have also to add water taken by the New River Company from the underground springs at Amwell, amounting to 5,868 cubic feet per minute.

13,722. (*Chairman.*) What do you do with them?—You will see immediately.

13,723. At present all we are to take is that there is such a supply at Amwell?—5,868 cubic feet per minute are pumped up from springs in the Lea valley for the supply of London, principally into the New River; the New River, as your Lordship is aware, comes from that district. Taking Mr. Baldwin Latham's gaugings from the 7th September to the 30th November, during, in fact, the whole period, the mean discharge over Teddington Weir amounted to 338,488 cubic feet a minute, to which we must now add the 7,778 cubic feet per minute, and by that we find the quantity draining from the 3,676 square miles of country above that point was 346,266 cubic feet per minute, or 94·2 cubic feet per minute per square mile; that is the drainage of the Thames above.

13,724. That is to say, of the Thames basin?—Yes; the Thames basin above Teddington Weir.

13,725. Does that include the Amwell supply?—No, because that is in the valley of the Lea. Now, if we take Mr. Baldwin Latham's gaugings from the 7th of September, we find that the mean discharge below Teddington was 61,709 cubic feet a minute, to which we have to add the water abstracted by the Lea, and the water abstracted from the springs, which is 5,868 cubic feet; that makes for the 1,486 square miles below Teddington 70,021 cubic feet per minute, or 47 cubic feet per minute per mile, being only half below what is delivered above.

13,726. I have not the slightest notion what you are driving at?—Having given you the figures, I will explain what I have said, that, according to the figures which have been placed before your Lordship by Mr. Baldwin Latham, the quantity of water delivered from each square mile above Teddington is twice as much as that delivered from each square mile below.

13,727. It is said so?—It is so.

13,728. You say it is so?—I say it is so, and I will give your Lordship the figures; it is an arithmetical calculation, and now I am going to explain why it is so.

13,729. The quantity of water that runs off each square mile of the Thames basin above Teddington Weir is double that which runs off each square mile of the Thames basin below Teddington, is that your proposition?—Yes, as shown by Mr. Baldwin Latham's figures, and I am now going to give you an explanation.

13,730. (*Sir John Coode.*) That is what Mr. Baldwin Latham says?—That is what Mr. Baldwin Latham says, and I agree with him, and I will explain to you the reason why. Now Mr. Symons put in certain tables of rainfall.

13,731. (*Chairman.*) What it matters is what I should like to know?—Your Lordship will see that it is of the utmost relevancy, I can assure you. Now Mr. Symons, who is the highest authority upon rainfall, put in a map and certain tables upon which he gave the rainfall during the same period; that is to say, September, October, and November, in certain districts which he has numbered on that map which I have here. I have made a slight correction in the tables for this reason: Staines has been accidentally put by Mr. Symons in the lower river, whereas Staines, of course is in the upper river, it is above Teddington; that was done inadvertently, of course. In the same way, Crawley has been put in the upper, whereas it should be in the lower; and Salisbury, which is many miles from the district, and Andover and Cheltenham should not be included in the watershed of the Thames, whereas they are included by him, and I have excluded those places.

13,732. Cheltenham is in the Severn basin, is it not?—Yes, it is.

13,733. If I am not mistaken, there is a large stream at Salisbury called the Avon?—There is.

13,734. And which runs out at Christchurch?—That is so.

13,735. There is also a small stream at Cheltenham called the Chelt, which runs into the Severn?—It does so.

13,736. (*Sir John Coode.*) How does this correction affect the result?—Very slightly; but the result is, that the rain during the three months in the upper basin amounted to 13 inches, and in the lower to $11\frac{1}{4}$. Now, of course, to be fair in our estimate, to arrive at a reasonable result, we must discount these relative rainfalls.

13,737. Why should you discount them if they are ascertained facts?—For this reason: we want first of all to ascertain the quantity which would be delivered; of course the quantity delivered in the lower Thames to the quantity delivered in the Upper Thames Valley would bear the ratio of the rainfall in the one to the rainfall in the other.

13,738. That depends upon the geological conditions and other circumstances?—I am assuming that the geological conditions are the same, and I say, supposing the surface of the ground were of a similar character, and would allow all the rain to run off, then the quantity of flow you would gain by gauging at Teddington would bear to that which you would obtain in the lower Thames the proportion that the rainfall bore in the one to the other.

13,739. Assuming the geological character to be the same?—Yes, assuming the geological character to be the same. That being so, instead of 70,000 cubic feet a minute, furnished by the 1,486 square miles below Teddington, there should be delivered 121,230, being in excess of the 70,000 gauged by Mr. Baldwin Latham by 51,209, and that difference or loss is, as Sir John at once perceives, due to geological considerations, and that is the point I am coming to.

13,740. There are other besides geological conditions?—Yes, such as where the country is more or less wooded, and the slopes, and the time it would take to run down, and the soil, and the evaporation. Now I am going to show why it is that the water which falls over Teddington Weir is so much in excess of that which is obtained by gauging the Lower Thames. This is the published geological map (*producing a map*).

13,741. (*Chairman.*) You are going to show why the water which comes over Teddington Weir is so much in excess of what?—Of the rain, which is found by gauging, delivered by the surface to the Lower Thames. I say that the water which comes over Teddington Weir amounts to 94 cubic feet per minute per mile, whereas that which is gauged by Mr. Latham below amounts only to 47 cubic feet per minute per mile.

13,742. You do not impeach the accuracy of Mr. Baldwin Latham's gaugings?—No, certainly not.

13,743. Does anybody impeach the accuracy of the other thing?—I may tell you at once the drift of the whole thing, but I want to put the story complete upon the notes. I am going to show that a very large quantity of the water finds its way into the Lower Thames through its bed by springs, and that that makes a very important difference indeed in the ratio of the upland water to the lower. I would now call your Lordships' attention to this enormous bed of chalk which forms the basin of the Thames (*pointing to the plan*); it is coloured pale green. It extends also above the lower green sand, crops out all along the southern coast, lies under the channel, and occupies a very considerable part of France. Now, I think I may dispense with that plan, as I have another which shows the matter much more clearly.

(*Producing a map. See Appendix* BP). This is the index map of the Ordnance, 10 miles to the inch. I have coloured upon that the outcrop of the gault. The gault upon the line coloured blue is from two to eight hundred feet higher than the level of high water. On the Surrey side, in Kent, it is not so high, but still it is sufficiently high to form a basin; it descends to a depth of about 600 feet, and it is perfectly impervious to water.

13,744. (*Sir John Coode.*) You mean a depth of 600 feet below the sea level?—Yes. The chalk and the gault run beyond the Thames Valley towards the sea, but owing to the incline of the strata the water which falls upon the chalk within the valley of the Thames finds its outlet in the valley of the Thames. The whole of the space left white within the valley of the Thames is chalk, and upon the section which will now be laid before you, taken from Merstham to Dunstable, the gault forms a perfect watertight basin. The whole of the surface of the chalk is singularly free from rivers, and I will show your Lordship directly where numerous "swallow holes," as they are called, exist, absorbing enormous quantities of water, the 5,868 cubic feet per minute pumped up by the New River Company being only a portion of that water. Now immediately above the gault, and forming the green line, there is the upper green sand.

13,745. Is the line of that section marked upon this map?—It is not, but I will have it put on. I should say this section is reduced from Mr. Whitaker's section, the geologist who was called by the Corporation, and who is an eminent geologist attached to the Geological Survey. This is identical with his sections, except that if it were drawn to the natural scale it would occupy the length of this room, and would be very inconvenient; therefore, the scale is distorted. The portion of that plan which is coloured pink is the outcrop of the tertiary beds, which are pervious to water. The portion coloured grey is the London clay; that is impervious, so that you have an enormous reservoir of water imprisoned between the London clay and the gault; that is the first step.

13,746. That is the reservoir from which the London brewers derive all their supply?—Now, I wish to point out to you what happens with regard to all that water.

13,747. (*Chairman.*) Your object now being to show that there is a larger amount of fresh water in the Lower Thames than would be attributable to water coming over Teddington Weir and what falls from rain immediately above it?—Yes.

13,748. (*Sir John Coode.*) That is your object?—That is my object.

13,749. There is more than visibly flows into it?—That is so. The water which has entered into the bed of the river above Teddington from rain and springs has come over the weir and been gauged, but the water which enters silently into the Lower Thames by springs has not been observed and has not been estimated, and would very seriously affect the result.

13,750. (*Chairman.*) You have gauged all the river supplies, such as the Dart, have you not?—Yes, all the surface water has been carefully gauged.

13,751. But you want to say that there is a quantity of unseen water that goes into the Lower Thames?—There is. I am now showing how it comes to be so, and then I am going to give you positive evidence that it is so. The sections I have now put before you (*handing in sections Nos.* 27 *and* 28, *Appendices* A.S. 1 *and* 2), are sections taken at right angles more or less to the course of the river through the Thames Valley Section No. 27 is from observations of my own which were taken for another purpose and continued for a twelvemonth. The names of the places show where wells extending to the chalk were dipped at intervals to show the level of the water, and your Lordship will see that whereas the water stands at Tring at 453 feet above the Thames, it falls gradually until at Isleworth it is at the level of the Thames. It is always being supplied from above; it is always escaping into the Thames and into the sea round the margin of the coast, either into the bed of the river or the sea.

13,752. (*Sir John Coode.*) This would be much more valuable if you had a key plan showing the lines upon which the sections were taken, and also the scale of this large section No. 26. (*See Appendix* AT). The scale is not mentioned?—I will have the scale put on; it is drawn to scale; it was really intended as a diagram. Now, the amount of rain which is absorbed by these surfaces may be gathered from the fact that there are 3,794 square miles of chalk exposed which drain into the Thames basin. This is according to Mr. Prestwich, who is looked upon as the best authority upon that subject. If you take the lower tertiaries, the chalk, and the upper green sand, all of which are pervious and admit the rain, we have upwards of 4,000 square miles of country which is absorbing a large proportion of the water which falls upon it.

13,753. The total area of the Thames basin is how much?—The total area is 5,162, adding the two together.

13,754. (*Chairman.*) The upper and the lower Thames valley?—Yes, altogether. Now I would wish to point out this. In many parts, where either the gault or the London clay meet the chalk, the rivers which had been formed upon less pervious strata disappear, being absorbed by the chalk. The Mole is so called because of the swallow-holes which exist between Dorking and Leatherhead. At Canterbury a very large number of swallow-holes exist at Farnham there are a very large number; at Newbury, at Hungerford, and in the valley of the Lea between Hatfield and Barnet, there are a series of streams or rivers which have no outlet whatever, but disappear, and are the feeders of the Amwell Spring, which is in the neighbourhood. I have coloured upon the ordnance the streams as they exist. (*Producing a Map. See Appendix* BQ). They have no outfall into any river at all, and could not have been gauged by Mr. Baldwin Latham.

13,755. Do you find these streams come to an end, as it were?—Yes; at South Mimms and at Mimms they have no other outlet than being swallowed up in the ground. They are called "swallow-holes" or "swilly-holes," and there is a very large extent indeed of them in the River Mole. There are some of them near Canterbury 50 feet in diameter.

13,756. And the River Stour?—The River Stour is kept clean by the water which has fallen on to the chalk and escaped through its bed; it scours away the mud, and keeps it clean. Now, I do not wish to occupy time further upon that, but will put the references upon the notes, because I would wish to refer the Commission to a paper by Mr. Prestwich.

13,757. There is another thing, which may fairly be mentioned now, upon which anybody can judge for himself. In many of the chalk districts there are no streams, and if you look on the Ordnance map you will find that it is so?—Between the Ravensbourne and the Medway there are no streams of any consequence. The Dart and the Cray are very small streams.

13,758. (*Sir John Coode.*) The chalk may be compared to a sponge, in fact?—I have a plan which shows the sections No. 27 and No. 28; they are laid down by blue lines on the map (*Appendix* BP). This was prepared for another purpose.

13,759. (*Chairman.*) Your theory, I understand, is this. There is the water, and it must get away, otherwise that which fell upon the land would be visible?—It must get away, and we find that the level all round the margin of the river is at the mean level of the water.

13,760. May not some of it get to the sea?—An enormous quantity of it gets to the sea, and I am going to show the importance of that as bearing upon this question.

*Mr. H. Law, M. Inst. C.E.*

29 May 1883.

13,761. (*Sir John Coode.*) I conclude, from your last answer, that you have directed your attention to the points where it does get into the sea?—Yes. Directing you to where you will find it, I would refer the Commission to Mr. Prestwich's paper in the Proceedings of the Geological Society, volume 10, page 222, and to Mr. Long's paper in the Proceedings of the Geological Society, volume 3, page 101, and to Mr. Clutterbuck's paper in the Journal of the Royal Agricultural Society, volume 25, page 306.

13,762. Could you give us a summary of them?—These are descriptions of the swallow-holes which exist at Canterbury, at Barnet, and at Farnham. There is one point I should like to mention, which is important, viz., the variation of the water-level. In the section No. 27, during the whole of the year the levels varied from ·58 of a foot near the Thames to 18·9 feet near Tring. The water in the chalk varied with the season, with the rainfall, below that height, so that the hydrostatic head was a little greater at some times of the year than at others.

13,763. What is there in these sections?—That is the mean. I would refer you to Mr. Barlow's paper, read at the Institution of Civil Engineers on the 5th of December 1854. It is in the Minutes of the Institution, Volume 14, and I can very briefly tell you the general subject of that paper. It was a suggestion that a large quantity of the water which finds its way into the Thames from the chalk should be intercepted by galleries running parallel with the river, and used for the supply of London. It was a suggestion made by Mr. Barlow to the South-eastern Railway Company's directors, he being engineer at that time to the South-eastern Railway Company. Mr. Ansted, the celebrated geologist, also made a report, of which I have a copy here. I need not read it, but the general purport of that report is this,—It was stated by Mr. Whitaker that the chalk crops out in the river first at Deptford. The chalk is in the bed of the river, coming down as far as Windsor, and thence, from Windsor to Deptford it is overlaid by the London clay, so that no springs can escape into the bed of the river from the chalk for that distance, but at Deptford the chalk begins to appear, and the tertiaries also, and continue until you get down to Tilbury. Through that length of the river large springs come out into the river and are visible at low water at spring tides. The particulars are given in the report of Professor Ansted and Mr. Barlow of visible springs at near low water.

13,764. (*Chairman.*) Do you know any very remarkable one—any large one?—There are numerous springs near Greenhithe, and if the Commissioners choose, when they are going down a low spring tide, they might themselves see the springs running into the river.

13,765. (*Sir John Coode.*) Have you seen them yourself?—I have. Now Mr. Whitaker, at Question 7014, is asked, "What is the fourth set?" that is in the enumeration of the strata he had described, and he says, "The fourth is the chalk, the lowest bed we "get in this part of the Thames valley." Then he is asked "Where does that extend from and to?" To which he replies "That extends from Deptford right "down the valley, being occasionally hidden, however, "from just below Woolwich to near Erith, by some of "the beds just described. In the neighbourhood of "Woolwich and from just above Erith to below East "Tilbury the valley is wholly cut in chalk." That is Erith, Long Reach, and the river below. Then he is asked, "Is the chalk a very permeable stratum?" To which he replies, "Yes, as a rule it is, especially "the part with which we have to deal here, that is to "say, the upper chalk." Then in his re-examination he is asked, at Question 7042, "I understand you to "say that no doubt the chalk does at its outcrop get "a considerable amount of rainfall into it." To which he answers "Yes."

13,766. (*Chairman.*) What is that gault you referred to a little while ago, is it a sort of chalk?—No, the gault is a very strong clay indeed, from which gault bricks are made.

(*Sir John Coode.*) It is one of the most tenacious clays you can possibly find, almost of the consistency of marl.

(*Witness.*) I wish to refer the Commissioners now to Diagram No. 29 (*producing the same, see Appendix* AU). This is merely a diagram expressing Dr. Way's determination of chlorine. If you will remember, Dr. Way put in certain tables which gave the quantity of chlorine upon the 14th and 22nd September and the 30th November at high and at low water, and the lines there shown express as ordinates the quantity of chlorine, and your Lordship will see that instead of being continuous lines as they would have been, if the chlorine had been a mean quantity, they all of them become elevated at Erith in consequence of the spring water which is entering the river there, diluting the sea water and making it more fresh, it is observable in all of them. Having pointed out that, I now wish to show the influence that that would have upon the tables which were put in by Mr. Mansergh as showing the percentage of sewage existing in the river upon certain days. I want now to show your Lordship the practical bearing, but I would first, in referring to Mr. Mansergh's tables, point out that Mr. Mansergh has over-estimated the quantity of sewage. I do not know how it arose, but Mr. Baldwin Latham, at Question 7688, took it at 64,158,122 from Crossness, and from Barking 84,005,145, making a total of 148,163,267, and that would give only 23,706,000 cubic feet per minute, whereas Mr. Mansergh took 26,000,000, why I do not know, there was no explanation of that. You will observe, upon Table M 3, Mr. Mansergh says that the sewage discharged at Barking is calculated at 14,760,000 cubic feet, and at 11,240,000 at Crossness, making a total of 26,000,000, which is 9, or nearly 10 per cent. in excess of that which Mr. Baldwin Latham had estimated more exactly by taking the population and the estimated quantity of water delivered. I, however, make the estimate of Mr. Baldwin Latham too high, for I have already given you the population actually drained in 1881. According to the census, which was then, as I said before, 3,880,102. Taking the increase as estimated by the Registrar General, which may be considered to be very exact, because it is founded on the relative birth and death rate, we must add to that 2 per cent. to arrive at the population in December 1882, about the time when these tables were made.

13,767. (*Chairman.*) This case will not turn on a matter 2 per cent.?—No, it is not a question of 2 per cent., but when the calculation is followed, as your Lordship will see, it makes a difference of cent. per cent. in the amount of sewage; that is to say, that population, taking 5 cubic feet per day per individual, (and Mr. Baldwin Latham only took 31·5, 5 cubic feet being equal to 32·5) gives only 13,742 cubic feet a minute; whereas Mr. Baldwin Latham has taken 16,296, and Mr. Mansergh has taken 18,055, and 18,055 as compared with 13,742, is in that respect alone a very important difference. So much for the quantity of sewage. Now I want to ascertain the quantity of upland water, and I have to refer to the mode in which Mr. Baldwin Latham and Professor Unwin estimated the quantity of water which was to be found in the Thames at Crossness on any particular day. Mr. Baldwin Latham was asked this question by Mr. Bidder in reference to taking the same quantity of water flowing past Crossness at any given moment as that which was at the same time coming over Teddington Weir; he was asked at question 8301, "Is not that necessarily erroneous, for this "reason, that the river water which came over Ted-"dington Weir upon the 14th is not the quantity "that is mixed down at, say, Crossness, upon that "day, and would not be mixed down at Crossness for "several days to come." To which he replied, "But I do not admit it to be an error, for according "to the theory of propulsion, whatever is put in at

" the upper end would push out an equal volume at " the lower end of the river." Then he was asked, " Do you mean to say that if we suddenly alter the " volume of the water that went over Teddington " Weir, that would produce an instantaneous altera- " tion at Crossness." To which he replied, " Yes, " or very shortly, in proportion to the rate at which " the impulse can travel. If you put a quart of water " in a long channel or a short channel, a quart will run " out at the lower end."

13,768. If that were true, if you threw a bucket of water upon the top of a house it would be upon the ground without any interval of time at all?—Yes, but this is of immense importance, because it affects the whole results of all the tables put in, as showing the percentage of sewage at any given time in the river. Your Lordship will see the bearing of it, and I think your Lordship already sees that what is here stated to occur is impossible. I only wish to show that it was said.

13,769. The river is not a rigid thing, in which, if you push one end you move the other?—But it is as clear as possible in the evidence, and I will take Professor Unwin upon the same point. Then Mr. Baldwin Latham, further asked, " So you consider that " you are justified, however many miles there are " from Teddington Weir to Crossness, in adopting " the quantity of water coming in at Teddington " Weir, as representing an equal quantity of river " water all the way down the river. To which he replies " Yes, I am justified in that." Then Professor Unwin is asked in cross-examination at Question 9706, " Although it is quite true that a certain " amount of fresh water poured in at the head of the " tidal section of a river must displace an equal " volume past every section; that is to say, assuming " that the same amount of water is put in every day " at Teddington, it is true that the same amount of " water must be pushed past every section of the " river in 24 hours, if the river is in its normal " régime; but in the first place, it does not follow " that the water which is pushed past is that " amount of fresh water, it may be mixed water," and Professor Unwin answers, " It does follow that " the same amount of fresh water must be pushed " past every section," Then he is asked " Why is " that. I am dealing with 100,000,000 cubic feet " poured in every day at Teddington. 100,000,000 " cubic feet must pass every section every day, but " that need not be fresh water," that is the question; he answers, " It is the simple mathematical law of the " continuity of the tide, that if you take two sections " of a river, the external conditions of which remain " constant, the inflow at one end is equal to the out- " flow at the other, and, further the inflow of each " material at the one end," and this is most remarkable, " is equal to the outflow of each material at the other, " otherwise the condition of the river changes." Now I do understand what he says there; what he says is this. If I come to day and find the river with a certain definite quantity of water in it, and I analyse that water and find that it has a certain chemical composition, and I come a month afterwards and find the conditions unchanged, both as to quantity and as to quality, I can then affirm that for every pint of any substance that was put in at one end a pint must have run out at the other, and he is quite right as to that; but it does not follow that it will run out upon the same day as it was put in, nor will you ever come a month afterwards and find the Thames with the same quantity of water in it, nor of the same chemical composition. Then he is asked at Question 9713, " So that the introduction of that extra 200,000 " cubic feet of water at Teddington coming down in " the sudden rush of a flood instantly purified to that " extent the river 50 miles away," to which he replies, " It instantly purified, to the extent of the " travel due to the upland water, the whole of that " water down to Southend; that is to say, in the " period due to one tide. The effect of a larger " quantity of upland water coming in at the top is " that the whole of the water is displaced down the " river by so much from the top of the river to " Southend"; that is to say, in the period due to one tide.

(*Chairman.*) I cannot tell how the gentleman could have said that it did such a thing; common sense tells you it could not, though ultimately it may have been so, no doubt.

(*Witness.*) But I should like to put upon the notes the whole of the scientific facts in three words. If you have a channel with water flowing through it, that channel having a considerable length, and you pour a large additional quantity of water in at the upper end, the effect is to increase the inclination of the water and gradually to increase the velocity all the way; but to say that if I were to pour into the Thames at Teddington suddenly a thousand tons of vinegar a thousand tons of vinegar would run out at Southend, I do not think that would commend itself to your Lordship; but that is what is said here, and upon that theory of propulsion is based the whole thing.

13,770. (*Professor Williamson.*) Do you mean to say that it is said to run out at Southend at the same instant as it is put in at the top?—Yes, it is so.

(*Sir John Coode.*) I think it hardly bears that interpretation.

(*Mr. Beaumont Morice.*) It does not.

(*Witness.*) Professor Unwin not only says it does flow out at the same time, but that it is the same quantity of each material.

(*Chairman.*) You must put a fair meaning upon it; he cannot have meant more than that what went in must go out.

(*Witness.*) But it is the application he makes of it, that I am going to point out.

13,771. (*Chairman.*) There may be an addition to it, as you say, from subterranean or subaqueous springs?—But this has an important bearing, as I will proceed to show; in fact, if I proceed with it you will perceive in two minutes the bearing that that has. If, for instance, instead of taking the water which was coming over Teddington Weir upon the 14th I take the quantity which was coming over seven days previously, that being the first record that I have in Mr. Baldwin Latham's tables, I get then 144,824 cubic feet per minute as against 118,000. That makes a very great difference with regard to the relative volumes of sewage and land water. If I now deduct from that the water supply, and add the spring water at 51,000 cubic feet per minute, and the sewage——

13,772. I beg your pardon; you are not giving us the whole of the rainfall in the Lower Thames Valley, which you have supposed not to be evident?—No. What I am doing is this. I am taking the deficit which there was in Mr. Baldwin Latham's gaugings of the Lower Thames as compared with the Upper Thames, and after making due allowance for the difference in rainfall, as the main quantity of the water would be delivered from the springs in the lower part of the Thames, and I think I am justified in doing that; it is only reasonable to suppose——

13,773. I do not know whether we are to go into it, but have you made any calculation of how much of the water that falls invisibly into the streams runs into the sea, and how much runs into the Thames; have you formed any notion of that; some of it runs into the sea, I presume?—Yes. Inasmuch as the gathering ground extends from beyond the upper part of the Thames Valley, I consider that I am quite justified in assuming that the quantity which escapes into the river along the margin of the river is proportionate to that which falls in the valley of the Thames, being confined, as it is, by the gault basin.

13,774. I may tell you my difficulty, if it is of any consequence at all. I understand you to say that it is manifest that in all reason there is as much rain falls in the lower valley of the Thames as in the upper?—Not that. I take the actual quantity by measure, and it is less, and I allow for it being less.

13,775. From its being in the east?—Not only

*Mr. H. Law, M. Inst. C.E.*

29 May 1883.

that, but it is not so high as the Upper Thames gathering ground; it is the height of the ground which affects the quantity of rain.

13,776. You say that all the rain that falls does not find its way into the Thames?—That is obvious.

13,777. It must go, surely, part of it, into the Thames, and would, you say, part into the sea?—Yes.

13,778. You think it is important to establish that, because that would show a greater dilution of the sewage than would otherwise exist?—Yes, no doubt.

13,779. Have you at all estimated the quantity that gets into the river of the whole deficit, if one may use such an expression?—Yes, I have estimated that at 51,207 cubic feet per minute upon the data which are upon the notes.

13,780. What proportion of the whole is that; how much goes into the sea?—The proportion which would go into the sea would form a very large quantity. I only assume that it is that which falls upon the Thames Valley, and is not accounted for which finds its way into the river; but there is a very large gathering ground, which is really in the valley of the Thames, which I have not taken into account at all; and, moreover, it is reasonable to suppose, that the water falling upon the chalk finds its way as directly as it can; that it will not go to the coast at a point 40 miles distant when it can reach the Thames at 20 miles; and, I may observe, that these sections I have put in actually show the fall of the water toward the Thames.

13,781. (*Sir John Coode.*) That it had been governed by the direction of the line of least resistance?—I would rather put it by the line of greatest fall, that is to say, the steepest gradient.

13,782. (*Chairman.*) You would give it all to the Thames, except where the sea could fairly compete with it, so to speak?—Yes; and to that upon this subject of the chlorine tests, I would add the influence of the drainage, not only from the east of England, but a large proportion of the drainage of the whole of Western Europe falls into the North Sea, and causes the water of the North Sea to be very much fresher than what the chemists take it to be, or than what they take as their standard for the purpose of their calculations. They never found it so salt as they said it ought to be, but they said the difference was due to the existence of sewage.

13,783. Do you say that the water of the North Sea is far less saline than that of the Atlantic?—It must be so. You have the Rhine, the Elbe, the Scheldt; you have the whole of the eastern half of England; you have a considerable portion of Russia, the whole of Prussia, the whole of Denmark, the whole of Holland, the whole of Belgium, the whole of Bohemia, the whole of Germany, and the whole of Switzerland draining into it; and it is impossible to have the rainfall from those countries draining into the sea without making the water of that sea fresher than that of the Atlantic.

13,784. You have a biggish river or two falling into the Atlantic, the St. Lawrence, the Mississippi, and the Amazon?—Undoubtedly.

13,785. Still, do not let us get into the ocean; let us keep to the narrow seas; what have you to say next?—The result of that calculation of the quantity of water which I have shown is 193,683 gallons, is to reduce the per-centage of sewage which Mr. Mansergh put at 15 per cent. to 7·1 per cent; as I say, therefore, cent. per cent. and more than cent. per cent. difference. The result of my calculation of the proportion of sewage to upland water upon the 14th September is 7·1 instead of 15 per cent.

13,786. One really ought to understand you, because you have taken an infinite deal of pains with it; do just tell me this, what additional fresh water do you mean, except this sub-aqueous or subterraneous contribution to the Thames? What other water do you add to that which gets into it below Teddington, otherwise than on the surface?—None.

13,787. But how much do you put it at?—The difference which is made upon the calculation, first, in consequence of spring water having been increased, and secondly, upon the assumption which has been made that the water which comes over Teddington Weir instantaneously appears at Crossness; those two together, I say, reduce the percentage of sewage and upland water from 15 per cent. to 7·1.

13,788. I cannot understand how that mistake or error, as you say it is, that it instantly appears at Crossness, arose, because it appears there ultimately?—That is just it. If I, upon the 7th September, have 144,000 cubic feet of water per minute over Teddington Weir, and if it takes a week for that water to reach Crossness, which is the fact, then I have to deal with 144,000 cubic feet per minute instead of the quantity which was actually coming over upon the 14th, which was only 118,000.

13,789. But what does that matter; in that space of time there is an average quantity comes down?—It matters this, a very delicate chemical test is made upon which I shall have something to say directly.

13,790. You are referring to something which has been taken out of the water?—Yes, I am.

13,791. That on some particular day they took something out of the water, and said that on that day a certain amount of water was flowing over Teddington Weir, which was true, but you say they ought to have looked at what flowed over Teddington Weir the week before?—Yes, you will see it in an instant. Their case is this: By means of the chlorine we can tell how much salt water there is; that being deducted from the whole bulk, leaves us the quantity of upland water and sewage; the ratio of the one to the other determines the quantity of the sewage, and that ratio is disturbed by the corrected calculation of the water; that is the whole process simplified.

13,792. Do I understand that there was more flowing over on the day of the experiment than was flowing over the week before, and that it was the water of the week before which had got down to the site of the experiment?—No; there was much less flowing over on the day of the experiment, and they assumed that what had got to Crossness was due to that day, and not to the water of the week before.

13,793. (*Sir John Coode.*) I thought it was the other way; that they gave rather a longer period than you are giving?—That was a totally different matter.

13,794. Did not Mr. Birch's diagram give a longer period?—That was a totally different matter. Mr. Birch's tables went to show that it did not matter how you dealt with this question; it would always lead to the same result.

13,795. (*Chairman.*) I should have thought it was against you, because they were ascertaining the percentage of sewage, were they not?—No, they did not ascertain that; they assumed that what they did ascertain was the absolute quantity of sea water in the river. They said, by means of the chlorine we can say what is the absolute quantity of sea water. The rest is a mixture of river water and sewage. Then if the river water that was there was only 118,000 cubic feet instead of 144,000 cubic feet; it left so much more for sewage. Now, I will address myself to the chlorine test itself, and the mode of dealing with the chlorine test.

13,796. What part of the river are you now going to speak of?—I am going to speak first of the estimate that the Corporation witnesses gave of the quantity of chlorine which was in the sea water when it came into the Thames, and upon which the whole is based. They made this assumption, that the sea water which enters the river from the North Sea always contains 1,961 parts in the 100,000 of chlorine, and if we find a less quantity of chlorine in 100,000 parts in any body of water, the difference is upland water, and sewage in the river. Now I contend that the 1,961 parts is far too high an estimate, and I base that upon this.

13,797. But suppose they were right, what re-

sulted from it?—That it showed a much smaller quantity of sea water than was actually present.

13,798. But where? — Everywhere where they wanted to determine.

13,799. It goes up as far as Chiswick?—Yes; but in order to determine the quantity of sewage at any given moment in any part of the river, they ascertained the quantity of chlorine, and if they found that the quantity of chlorine was less than there should be in sea water——.

13,800. That is to say they said in effect, we will show you that sewage exists to a certain extent, even at Gravesend, because we will show you the constituents of the water, and that involves a certain percentage of sewage matter; that is one of their propositions, is it not?—Yes, it is one of their propositions.

13,801. Then against that you say, If they had put the matter right it would have shown a less proportion of sewage there?—Yes, that is so.

13,802. But inasmuch as you know the river, and, consequently can gauge the quantity that comes in of upland water, and the quantity that comes in from the bottom, what is the use of going into a speculation of this sort?—Because it is one of the grounds upon which they have based the alleged pollution of the river to the degree to which they show it to be polluted. You have positive statements here that the river was polluted. You have the statement made here, that at Crossness, upon the 14th September, the whole body of the river contained 11·7 per cent. of sewage. If that were so, it is a very serious matter, that more than a tenth, in fact, nearly an eighth, of the whole river was sewage.

13,803. Cannot you get that to a certainty by telling the quantity of fresh water that comes in as compared with the sewage with which it is mixed?—Yes, and that is just where this estimate of the spring water and so forth has such a very important bearing upon the question.

13,804. Your view would corroborate your notion of underground supplies?—Yes. Now I wish to refer to Professor Way's Table No. 2, put in by him, in which he gives an analysis of the sea water at Margate upon the several days, beginning with October 29th and extending to the 30th November, and the mean of the chlorine in the water of all those observations is not 1,961 but is 1,899, and on no single occasion did it ever reach 1,961. The highest was on the 2nd November 1852, when it reached 1,951.

13,805. I suppose that is a difference of between 3 and 4 per cent., is it not?—Yes. Then the lowest was 1,737 at Margate, the mean, as I said before, being 1,899. And that is confirmed again by the mean of certain observations which he gives to your Lordship, which, curiously enough, also come out at 1,899. Now, if we take the mean of the sea water at Brighton, at Penzance, and other places, and in the Atlantic, as given by Dr. Frankland in his Table No. 3, we get at 1,900, which is nearly identical with Professor Way's mean; and curiously enough in the mid-Atlantic Dr. Frankland gives only 1,800, so that there cannot be a shadow of doubt, taking the water coming into the Thames from the North Sea with all this land draining into it, and also the water coming into it from the chalk, as we know all round the coast it does, and as I know from personal observation it does—I say, to assume that the sea always contains absolutely 1,961 parts of chlorine to the 100,000, and that if upon any day you find anywhere near the Thames a deficiency in that amount, you must attribute that deficiency to land water, containing sewage, is, I think, an assumption not borne out—it is somewhat unreasonable. Now, so much for the quantity of chlorine in the sea. I now want to make a remark upon the quantity estimated to be in the river itself; certain days are taken the 14th September, the 22nd September, and the 30th November. I will deal with the 30th November. Drawing No. 31, (*See Appendix* A.W.) is a longitudinal section of the river from Southend to North Woolwich, and it shows the positions in which the samples of chlorine were collected upon the 30th of November. On this day, the 30th of November, only two samples were taken at each spot—one was taken as shown upon the surface of the water, one was taken at 20 feet below the surface of the water. In some parts of the river, as the section shows, the depth of the river is 80 feet. Between Gravesend and South end Pier you will see on the section a very deep part. We have here a distance of 27 miles, and we have the assertion made, that by taking two samples at Erith and two samples at Southend, a distance of 27 miles apart, and the lowest sample only extending to 20 feet below the surface, when some parts of the river were 80 feet in depth, you get a fair representation of the mean quantity of chlorine throughout the whole length of the river, with sufficient exactness to enable you to say positively what is the composition of the water, and to determine that there is so much sea water, and consequently so much sewage; that is the proposition that has been laid before the Commission. Now I wish to point out from actual observation, the variations which occur in the composition of the water, as regards chlorine in very short distances. The analyses upon which this table is founded will be put in before the Commission by the chemists, and of course it will be regularly proved; the samples are all numbered, and this table (*producing Table No.* 8) contains the localities, the date, the state of tide, the number and position of sample, the amount of chlorine found, and the percentage of difference between two samples taken within short distances and at small intervals of time. By "short distances" I mean either at the surface, and at the bottom, or in the middle of the river, and on one side of it, and at the same points within a few minutes. The variations in these cases shown by the table are 10 per cent. in some cases, and 36·6 per cent. in others.

*Table No.* 8 *was handed in, and is as follows:—*

TABLE showing the VARIATIONS in the QUANTITY of CHLORINE in SAMPLES of THAMES WATER taken within short Distances and at small Intervals of Time.

| Locality. | Date, 1882. | State of Tide. | No. of Sample. | Position of Sample. | Amount of Chlorine. | Percentage of Difference in Amount of Chlorine. |
|---|---|---|---|---|---|---|
| | | | | | Grs. per gall. | |
| Greenwich - | Aug. 15 | Low water. | 284 | North shore | 33·3 | 12·9 |
| | | „ | 283 | Midstream - | 29·5 | |
| „ - | „ | High water | 279 | South shore | 258·4 | 12·7 |
| | | | 281 | North „ | 291·2 | |
| „ - | Aug. 19 | Low water | 315 | „ „ | 37·27 | 10·9 |
| | | | 314 | Midstream | 33 61 | |
| „ - | Aug. 24 | Half ebb - | 342 | North shore | 126·29 | 11·3 |
| | | | 340 | South „ | 138·51 | |
| Blackwall Pier. | July 22 | „ | 170 | Midstream surface. | 35·5 | 12·7 |
| | | | 171 | Midstream bottom. | 40·0 | |
| „ - | Oct. 16 | Half flood | 445 | Midstream surface. | 820·0 | 14·2 |
| | | | 446 | „ | 936·8 | |
| Woolwich Arsenal. | July 31 | High water | 194 | North shore | 323·0 | 12·9 |
| | | | 192 | South „ | 364·6 | |
| „ - | „ | Low water | 197 | North „ | 51·70 | 10·3 |
| | | | 195 | South „ | 57·03 | |
| „ - | Aug. 5 | „ | 239 | Midstream - | 122·22 | 13·3 |
| | | | 238 | South shore | 133·51 | |
| Barking Reach. | Aug. 1 | „ | 203 | North „ | 94·43 | 35·7 |
| | | | 202 | Midstream - | 69·58 | |

*Mr. H. Law, M. Inst. C.E.*

29 May 1883.

| Locality. | Date, 1882. | State of Tide. | No. of Sample. | Position of Sample. | Amount of Chlorine. | Percentage of Difference in Amount of Chlorine |
|---|---|---|---|---|---|---|
| | | | | | Grs. per gall. | |
| Barking Reach. | Aug. 1 | High water | 199 | Midstream - | 405·05 | 16·4 |
| | | | 198 | South shore | 347·90 | |
| Tripcock Point. | Aug. 2 | Half flood | 205 | Midstream - | 357·81 | 28·6 |
| | | | 204 | South shore | 278·30 | |
| Near Barking Outfall. | Aug. 3 | „ | 223 | Midstream surface. | 280·00 | 11·4 |
| | | | 224 | Midstream bottom. | 312·00 | |
| Crossness Point. | July 22 | Low water | 153 | Midstream - | 164·00 | 36·6 |
| Halfway Reach. | „ | „ | 156 | „ | 224·00 | |
| Erith - | July 27 | Half flood | 177 | Midstream surface. | 355·00 | 20·6 |
| | | | 178 | Midstream bottom. | 428·00 | |
| Erith Causeway. | Aug. 2 | Three-quarters flood | 211 | North shore | 571·60 | 17·4 |
| | | | 209 | South „ | 487·00 | |
| „ - | Aug. 4 | High water | 236 | Midstream - | 629·4 | 22·5 |
| | | | 235 | South shore | 531·6 | |
| „ - | Aug 10 | „ | 257 | North „ | 596·8 | 11· |
| | | | 255 | South „ | 533·7 | |
| „ - | Aug. 12 | 1 hour after high water | 271 | Midstream - | 500·5 | 11·4 |
| | | | 270 | South shore | 449·4 | |
| Purfleet - | Aug. 26 | High water | 361 | Midstream surface. | 695·8 | 10·0 |
| | | | 360 | Midstream bottom. | 765·1 | |

13,806. (*Sir John Coode.*) You do not mean to say they vary from 10 per cent. to 36 per cent. at the same points, do you?—Very nearly. At Blackwall Pier on July 22nd, half ebb, between the surface and the bottom in mid stream it varied 12·7 per cent.

13,807. Were they taken at the same moment?—They were taken at the same moment as nearly as they could be, by the same observer, within three or four minutes. I have one taken near Barking Outfall, on August 3rd, at half-flood, where the difference between the surface and the bottom was 11·4, and I have one taken at Erith on the 27th July between the surface and the bottom, the variation being 20·6 per cent.

13,808. Do they seem to follow anything like a regular rule, varying according to the depth?—No, they are very much disturbed by the spring water coming in, and some of the variations which occurred in the analysis at Erith may be attributed to those two circumstances, the spring water and the depth.

13,809. I understand you to say that the variations are so great, that they must be attributable to something of the kind?—Yes, there are two things; the set of the tide, the flood tide cutting up through the river, and the spring water coming in and diluting the water of the river. Now I wish to call your attention to Diagram No. 32 (*producing the diagram. See Appendix* A.X.) Mr. Mansergh laid before you the tables to which I have previously referred, M. 3*d*, in which he shows you a certain quantity of sewage existing in the river at low-water upon the 30th of November, and he also shows that upon the subsequent flood tide, no sewage having been admitted into the river in the interim, there was an increase in the quantity of sewage between Southend and North Woolwich of 108,073,126 cubic feet or a discharge of 5½ days sewage from the metropolis, which must have come from the North Sea, so that 5½ times as much sewage is capable of coming in in one tide from the North Sea, as from the Outfalls of the Board. These figures were absolutely given by Mr. Mansergh. Column 10 being, at low water, added up, amounts to 297,600,583; while the succeeding high water of that same day, adding up column 10, comes to 405,683,709, or the difference I have stated, which is equal to the whole sewage of London for 5½ days, which must have come into the river miraculously.

13,810. Were they both at high water?—At low water, and the succeeding high water, no sewage having been discharged in the interim.

13,811. (*Chairman.*) Let me understand. You say that the evidence given against you shows at the time of high water five times as much chlorine as there was at the previous low water; is that so?—No, it shows 108,000,000 cubic feet more of sewage in the River Thames from the outfalls downwards at high water than there was at the previous low water, no sewage having been discharged in the interim.

13,812. (*Professor Williamson.*) Is it in the same or in a particular area of the Thames?—In the whole area, extending from Woolwich to Southend.

13,813. (*Chairman.*) Does it show that the chlorine in a certain district had augmented in quantity?—No, the assertion is this: here is a column which is headed "Quantity of sewage in each division;" that is the absolute quantity of sewage alleged to be there.

13,814. They have got at that from the quantity of chlorine?—They have.

13,815. Then you say to qualify that, that if that statement of theirs is right, it follows that there was 5½ days more sewage in the river at high water than at low?—A difference of 5½ days.

13,816. It follows that there was more sewage at high water, when nothing but fresh water from the sea had come in, and no sewage had come in, than there was before?—It does show that?

13,817. Is it a possible explanation that the sea could have returned the discharge?—Do you mean of the 5½ previous days?

(*Chairman.*) Yes.

13,818. (*Professor Williamson.*) Would you kindly state, because I have no doubt you have it in your mind, what proportion this bears to the total amount of sewage in the river; that is to say this 5½ days accumulation; is it an error of two or five per cent., or is it an error of 30 per cent.?—The Commission will see how I arrive at these figures.

13,819. (*Sir John Coode.*) But how do you arrive at the quantity of sewage being 5½ days?—By multiplying the quantity which is about 23,000,000 feet by 5½ it will come to about 108,000,000.

13,820. (*Chairman.*) Those figures show the bulk of water at high water?—Yes, they do.

13,821. They show the proportion of sewage in it?—They do more than that; they show the absolute quantity in figures.

13,822. They show the quantity of sewage?—Yes, they do.

13,823. You say that quantity is equal to 5½ days average discharge?—It is so.

13,824. Then, inasmuch as none had been poured into the river after low water, it follows that that must all have come back from the sea?—Yes, if it was there.

(*Professor Williamson.*) It is important to know what proportion this bears to the total quantity, and how many days are usually stored up in the river.

13,825. (*Chairman.*) Now, I will ask you this; of course the river is not empty at low water?—No; it would contain about half as much at low water as at high.

14,826. (*Sir John Coode.*) I understand you to say you there refer to Table M 3*d*?—In the divisions between Crossness and Southend, Mr. Mansergh alleges that there are so many million cubic feet of sewage in the river, in each particular division upon the date to which these observations refer. Then, I say, adding up the totals at low water and at high water when no sewage had been discharged, the

difference is equivalent to a discharge of five-and-a-half days of sewage.

13,827. (*Chairman.*) And the total quantity would be equivalent to 11 days, would it not?—No.

13,828. What I want to get out is this; half of it had not run out, you say, because at high water there was double the quantity of water in the river that there was at low water. Therefore, half the water had not run out, consequently, it is only half that had come in from the sea?—It is not half that came in from the sea; they allege that the quantity that was contained in the river at low water amounts to more than five days; they say that there were seven or eight days' sewage in the river at low water, but that at high water there were 12 days sewage.

13,829. Then it is about five days which had come from the sea?—That is all.

If you start with a datum of seven days sewage at low water, and find 12 at high water, you have five days coming back from the sea.

(*Witness in answer to Professor Williamson.*) I find it is just 36 per cent. of the whole quantity.

13,830. (*Chairman.*) Do you say that the witness's statement is wrong?—I say it is physically impossible; I will put it quite as high as that. This same diagram that you have before you will show that it cannot be. If you look to the upper diagram on your right hand, you will see a diagram to show the way in which the mean of the chlorine was taken. For instance, a sample is taken at the top of the water, and is found to contain 290 grains, a sample is taken 20 feet down, and is found to contain 338 grains; those are added together, divided by two, and that is called the "mean composition of the water." Now, if that is so, taking a water which increased in saltness from 290 to 338 in passing 20 feet down, by the time it got to the bed of the river they have assumed it to have got equally fresh to what it was at the surface, instead of increasing in the ratio that it did between 1 and 20 feet, and when you come to a depth of 80 feet in a length of 27 miles of river with all its varying circumstances, and trust to an observation at each end to give you the quantity of chlorine, I do think that observations founded upon that slender basis are not sufficiently accurate to draw such very important conclusions from.

13,831. (*Professor Williamson.*) There is one point which I should be glad if you would be good enough to inform me about, because you have the figures more clearly in your mind as given by the other party, what do you attribute to them as their view of the matter, as to the conditions of the river at high and low water respectively; do you take it to have been stated by them, that at low water the downward range of the sewage has the same proportional dilution as at high water at any particular point, that is to say, whether at low water when a great deal of the water that was in the river has run out, the sewage is found further down than it was at high water, that if it were the case that a good deal of this sewage mixture, which was up, we will say, at London Bridge, at high water, has gone, at low water, down towards the Nore, then at high water this stuff would come up again, and not water from the North Sea. Would that have been their meaning?—No, this must have been water from the North Sea, because the whole of the water in the whole length of the river is included in this valuation.

13,832. You mean that what gets beyond goes down channel and up channel?—That is so. Now the next question is as to the quantity of chlorine in the river water. We have had the quantity of chlorine in the sea water, and we now come to the quantity of chlorine in the river water and the sewage mixed. In the estimates which they have made, they have taken the river water as containing 1·7 parts of chlorine in 100,000, but the water which enters by springs, especially when it comes from underneath the clay (as the largest proportion of the chalk water coming into the Thames does come), contains from 30 to 5 parts in the 100,000 of chlorine. I have taken the mean of 10 as against 1·7, so that if we take the discharge over Teddington Weir upon the 14th September, which I allege was 128,734 cubic feet per minute, at 1·7 parts, and take the 51,000 cubic feet, which, I say, comes in at the springs at 10, it gives as the mean quantity of chlorine in the water four parts of chlorine in 100,000 instead of 1·7. If, therefore, we now apply the principle, which I do not dispute, I say the chlorine test is in theory a very beautiful thing, and undoubtedly is theoretically perfectly correct; if you have accurate quantities to deal with, and you know that they express the mean values, you will get an accurate result. I say if you apply it upon this basis you will get a very different result.

13,133. (*Sir John Coode.*) Do I understand you to say that the quantity of chlorine in these springs has been arrived at by the actual analysis of the springs in question, which are flowing into the Thames?—Some of them.

13,834. Because you will see that a great deal will turn upon that?—At page 103 of the Sixth Report of the Rivers Pollution Commission there are several analyses of chalk water, the nearest I find here is at Witham, in Essex, which I think we may take as the water which would be finding its way to the Thames.

13,835. But you have not got it at the point near where it issues into the Thames, have you?—I have one analysis of Professor Way's.

13,836. (*Chairman.*) Do you say that the water at Witham would find its way to the Thames?—It is the water which is already on its way to the Thames; it is water from a well which is then flowing to the Thames.

13,837. (*Professor Williamson.*) Do you assume that after percolating through a considerable thickness of soil, it would be of the same composition as on entering?—These are analyses of the water from the wells.

13,838. That is where it goes in?—No, this is where it is taken out at Witham.

13,839. But you are assuming, are you not, that this water, as I understand at Witham, soaks through chalk or soil so as to get to the Thames?—No, I am not. Witham is one of the points of outlet, Witham lies low, and Witham is one of the points of escape. We have another example at Braintree, in Essex; there there were 38·8 parts of the chlorine in 100,000 parts.

(*Sir John Coode.*) The point is the constituent parts of the water where it absolutely flows into the Thames; that is the point I want to be clear about.

(*Mr. Beaumont Morice.*) From Witham would be some distance round to get to the Thames.

(*Witness.*) Thére is no fact better known, as shown by these analyses, than that where you have a water from the chalk from underneath the clay, it does contain these large quantities of chlorine, and that that is the exact condition in which the water which flows from the Thames does flow in.

13,840. (*Professor Williamson.*) That it usually contains 10 parts in 100,000?—It usually contains 15; the 10 is the mean.

13,841. And at Braintree?—At Braintree it is 38·8.

13,842. Have you any analysis of the water, as it is flowing into the Thames?—Not as it is flowing into the Thames, but I have from the South Essex waterworks, which are close to the point of the water flowing into the Thames, and from Professor Way's analysis it is 13·3 to 13·6 parts in 100,000.

13,843. *Sir John Coode.*) And that is pumped from a deep well, whereas the water at Witham is on the surface, if I understand you rightly?—No, the water there is in a deep well.

13,844. If you could give us the proportion of the chlorine in the water as it flows immediately into the Thames, that would be the point which I should like to have?—That might be taken.

13,845. (*Chairman.*) Where did the other side take their samples from; were they taken from water flowing over Teddington Weir?—Yes, they were

*Mr. H. Law, M. Inst. C.E.*

29 May 1883.

taken from water flowing over Teddington Weir, which gave 1·7.

13,846. (*Sir John Coode.*) I must say that for my own satisfaction I should like to have the water analysed at the point where it goes into the Thames; anything else is an inference?—Now, pursuing exactly the same calculation as that adopted by Mr. Mansergh, the result is, that instead of showing upon the 14th September 8·9 per cent., as he does show, in Table M 3*b*, in the division immediately below Crossness, as the quantity or percentage of sewage in the river upon that day, I make it 4·19, which is again just about cent. per cent. difference. Again, I would call the attention of the Commission to the fact that although Mr. Birch brought out a diagram in which he said he had not taken the rough-and-ready way of arriving at the result, which Mr. Mansergh's and Mr. Baldwin Latham's experience had enabled them to do, but that he had gone into it with greater exactness, I have compared the results which he so gives with the results of Mr. Mansergh's table for the 14th September, taking the six divisions below Crossness. I will not read the figures, but the result is this, that in the first division Mr. Birch's estimate is 8·9 per cent. more, in the next 3·31, the next 5 per cent., the next 14 per cent., the next 39 per cent., and the next 44 per cent., in excess of Mr. Mansergh's estimate upon the same day; Mr. Birch's average of the whole length of the river from Crossness to Southend being in excess of Mr. Mansergh's estimate by 16¾ per cent., whereas Mr. Birch said he had brought his forward to confirm Mr. Mansergh's. If you take the absolute quantity of upland water and sewage as given by Mr. Birch and Mr. Mansergh upon those days, the differences vary from 1½ per cent. less in the third division, to 20 per cent. more in the fifth division. Then if you take the percentage of sewage to upland water, that varies again in Mr. Birch's estimation and Mr. Mansergh's from 4 per cent. to 20¾ per cent. Those are the discrepancies in the figures given by two estimators upon the same data. Then I observethat in these tables of Mr. Mansergh's, lettered M, he assumes that in every case the quantity of upland water is constant from Erith downwards, whereas Mr. Baldwin Latham makes it increase upon the 14th of September by nearly 7 per cent. Mr. Mansergh makes the quantity of upland water and sewage in his column 9 constant every day for 27 miles of the river below Erith; he makes it the same at Southend as at Erith, and the same at high water as at low water. It is absolutely impossible, that is to say, thatt he proportion of the upland water to the sewage water never varies during the 24 hours; that whether you are at Erith or at Southend, whether the sewage has been discharging into the river, or the sluices are shut, that the percentage of sewage to upland water is always the same; it is quite impossible.

Adjourned to to-morrow at half past 12 o'clock.

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# THIRTY-SIXTH DAY.

## Wednesday, 30th May 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
JAMES ABERNETHY, ESQ., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, ESQ., F.R.S., *Secretary.*

MR. HENRY LAW called again; further examined by MR. NORMAN BAZALGETTE.

30 May 1883.

13,847. I believe, first of all, you wish to add something or to say something about the observation you made yesterday with respect to the capacity of the outfall sewers?—I wish to say that we have since ascertained the quantity of rain which fell last Saturday. I find that between 9 in the morning and a quarter after 12 in the day $\frac{17}{100}$ths of an inch of rain fell, and between half-past 4 and 6 o'clock $\frac{15}{100}$ths, making together $\frac{1}{3}$ of an inch in 9½ hours, and that although only two out of the three sewers were at work, no overflow occurred at any part of the system.

13,848. (*Sir John Coode.*) Was there nothing falling between 12 and half-past 4?—Yes; these are the observations made at Spring Gardens; and being at the outfall myself I can say there was a drizzling rain during the interval. The system, therefore, which was provided for a quarter of an inch in the 24 hours with the three sewers was sufficient to take the rain at the rate of one-third of an inch in nine hours when only two of the sewers were at work, and no overflow occurred at any part of the system, and that rain was running off during the period of the maximum flow, because the maximum flow was at half-past 2.

13,849. (*Mr. Norman Bazalgette.*) When we broke off yesterday, we were speaking upon the subject of the chlorine tests; have you anything to add to what you said yesterday?—I would first hand in Table 8*a*, showing the difference between Mr. Birch's and Mr. Mansergh's estimates of the sewage in the river below Crossness, to which I referred yesterday.

[*The Table No.* 8a *was handed in, and was as follows:*—

COMPARISON of the Estimates of Mr. BIRCH and Mr. MANSERGH of the quantity of PREVIOUS SEWAGE in the Six Divisions of the River below CROSSNESS, on the 14th of September 1882, as determined by the Chlorine test.

ABSOLUTE QUANTITY of PREVIOUS SEWAGE.

| | Mr. Birch's estimate. | Mr. Mansergh's estimate. | Percentage of difference upon Mr. Birch's estimate. |
|---|---|---|---|
| 1st division - | 140,400,000 | 152,913,468 | 8·91 per cent. more. |
| 2nd " - | 137,800,000 | 142,360,747 | 3·31 " " |
| 3rd " - | 117,000,000 | 123,041,069 | 5·16 " " |
| 4th " - | 117,000,000 | 131,321,201 | 14·24 " " |
| 5th " - | 104,000,000 | 144,895,591 | 39·32 " " |
| 6th " - | 91,000,000 | 131,079,694 | 44·04 " " |
| | 707,200,000 | 825,611,770 | 16·74 " " |

ABSOLUTE QUANTITY of UPLAND WATER AND SEWAGE.

| | Mr. Birch's estimate. | Mr. Mansergh's estimate. | Percentage of difference upon Mr. Birch's estimate. |
|---|---|---|---|
| 1st division - | 843,815,520 | 955,709,177 | 13·26 per cent. more. |
| 2nd " - | 962,171,097 | 949,171,646 | 1·36 " less. |
| 3rd " - | 832,852,157 | 880,272,798 | 1·61 " .. |
| 4th " - | 837,940,545 | 875,474,877 | 4·48 " more. |
| 5th " - | 803,961,416 | 965,970,608 | 20·15 " .. |
| 6th " - | 732,762,075 | 873,864,633 | 19·26 " .. |
| | 5,013,502,810 | 5,440,364,539 | 8·51 " .. |

PERCENTAGE of SEWAGE to UPLAND WATER and SEWAGE.

| | Mr. Birch's estimate. | Mr. Mansergh's estimate. | Percentage of difference upon Mr. Birch's estimate. |
|---|---|---|---|
| 1st division - | 16·68 | 16·00 | 4·08 per cent. less. |
| 2nd „ - | 14·32 | 15·00 | 4·75 „ more. |
| 3rd „ - | 14·05 | 15·00 | 6·76 „ „ |
| 4th „ - | 13·96 | 15·00 | 7·45 „ „ |
| 5th „ - | 12·93 | 15·00 | 16·01 „ „ |
| 6th „ - | 12·42 | 15·00 | 20·77 „ „ |

Then I would point out that another circumstance which would appear to throw some doubt upon the conclusions drawn from the chlorine tests upon the 14th September, would be that they show that at St. Paul's Pier at high water there was 12 per cent. of sea water there, which is almost an incredible thing. Up to a few years back the Lambeth Waterworks took almost the whole of their supply from a point close to Waterloo Bridge, from a point very little above the point where it was alleged that the water was liable to have 12 per cent. of sea water in it. I do not think therefore that it could ever be so. I have only one more matter to add with regard to the chlorine tests, and that is a short calculation as to the result shown by Table M3*C*. of Mr. Mansergh. Referring to Table M3*C* it is there shown that in the 6th Division, that is the last division above Southend, there were 13,686,000,000 of mixed water, and that is stated to contain in each volume (that is dividing it by cutting off five noughts) 1,700 parts of chlorine. If therefore we multiply that number by the 1,700, we shall obtain the quantity of chlorine that was contained in the whole quantity of water in that division. If we then deduct from that the quantity alleged to be in the sewage, there were alleged to be 600 volumes of sewage containing each 10 parts; that gives 6,000 parts of chlorine. Then, again, if we take the quantity of sea water alleged to have been there, which is 118,000 volumes, and multiply that by the 1,961 parts which are stated to have been the quantity of chlorine in the sea water, those two last amounts deducted from the preceding leave the volume of chlorine in the sea water, which must have existed in that part. If we now divide that by 1·7, which is the quantity of chlorine alleged to be in every volume of land water, we arrive at the fact that there must have been 61,000,000,000 cubic feet of upland water, which is 34 times the quantity which Mr. Mansergh states in another column to have been there; four times the whole quantity of water in that division of the river, and 40 per cent. in excess of the whole quantity of water in the river from Teddington to Southend.

13,850. (*Chairman.*) I should think you have not the slightest hope or expectation that I understand a word of what you are saying, have you?—It is a simple calculation, which your lordship will have no difficulty in following when it appears on paper.

13,851. Although an accomplished mathematician might understand it, and I claim some small acquaintance with figures myself, would it not be better that you should state your conclusion, and give your reasons for it?—I am doing so. It proves that if the slightest value is to be attached to this table, the upland water in the river was 40 per cent. in excess of the whole of the water there.

(*Mr. Lumley Smith.*) It proves that the table was wrong.

13,852. (*Chairman.*) It shows that all the water there was what?—That it must have been river water, and a good deal more as well. I put that proposition before you, it is for the other side to contradict it. I say the test is one of such delicacy that it is impossible to draw any conclusion from it, except that they have been unable to take such an enormous number of observations simultaneously as to enable them to give you accurate data; but to take observations as they did at Southend and at Erith only, and then to assume that that gave them the whole composition of the water in the 27 miles intervening, it is that which upsets the whole conclusions of the table.

13,853. It goes to show that there was 40 per cent. more water than there was there?—Yes, if the table is right, that is the inevitable conclusion.

13,854. It practically comes to this, that the table is wrong?—Yes, the table must be wrong. Now I have only one word to say with regard to Professor Unwin's tables, and that is this: the tables of Mr. Mansergh, Professor Unwin, and Mr. Birch professed to give you results drawn from the same data in confirmation of each other; but if we compare them, taking only one day, the 14th September 1882, at high water, Mr. Mansergh states the total volume of the river above Crossness to have been 4,211,000,000, Professor Unwin states it to have been 4,397,000,000, or 4½ per cent. in excess; but if we take the total volume below Crossness we find the percentage in excess on the part of Professor Unwin over Mr. Mansergh is 27 per cent., which, is a very important difference; those are the errors in Table 2, they affect Table 3 and Diagram No. 1. Then Table No. 4 is entirely fallacious, because in it is assumed the theory of propulsion, which as I explained yesterday, is inadmissible; and the fallacy in Table No. 4 affects the whole of the subsequent tables. Then taking the same high water, comparing Mr. Mansergh and Professor Unwin, we find the total sewage in the river above Southend, according to Professor Unwin, is 15 per cent. in excess, and we find, if we compare the sewage above Southend at low water with the sewage at high water, while Mr. Mansergh makes it 13,000,000 less at high water, Professor Unwin makes it 10,000,000 more.

13,855. (*Mr. Lumley Smith.*) More than what?—At high water than at low water.

(*Mr. Norman Bazalgette.*) Now we will go to another point, what do you say as to the capability of the river to purify the sewage discharged into the river.

(*Sir John Coode.*) This I suppose is in respect to volume, not chemically.

(*Witness.*) No, not chemically, beyond merely stating the quantities. I do not profess chemical knowledge, or to deal with the subject from a chemist's point of view. Now Dr. Tidy told us, reading from page 11 of his paper laid before the Chemical Society on River Water: "On the other hand, I contend, if "sewage be discharged into a river in such proportion "that the pure water is at least 20 times the volume "of the sewage, that, after a moderately rapid flow "of a few miles, the whole of the impurities will by "oxidation and other agencies disappear, and the "water be again restored to its original state of "purity"; and at page 20 of his paper he sums up in these words: "Given then a fairly rapid river that "has received sewage in quantity not exceeding, say, "one twentieth part of its volume, is there evidence "to prove that after the run of a few miles the water "of that river will regain its purity and become "wholesome and good for drinking? To this "question I answered unhesitatingly, there is "undoubted evidence of such purification; and the "evidence I have adduced has been of a fourfold "nature, physical, chemical, medical, and statistical." Now I made a calculation to enable me to tell what proportion of pure water you would have to receive the sewage poured into it at the outfalls. The first element in that calculation is the quantity of water which will pass upon the ebb tide, and I have taken an average ebb tide, viz., that which occurred upon the 3rd of October 1882, when I find that almost all the conditions were those of an average tide midway between neaps and springs, and when the upland water at Teddington was at its average value or quantity. In order to determine the quantity of water which will flow out in a tide, we want to know the exact level of the surface of the water when it is high water at Crossness, and we want to know the exact level of the water in the river when it is low water at Crossness; and it is perfectly evident that

*Mr. H. Law.*

30 May 1883.

the whole bulk of water contained between those two planes with the water coming over Teddington Weir during the seven hours of that ebb tide must be the quantity which passed Crossness and Barking upon that tide. I have a diagram here (*producing a diagram*; *see Appendix BO.*) upon which the heights are plotted to the tenth of every tide, from tidal observations which were taken by the registering instruments, and which enable me to calculate with accuracy the volume of the water so discharged; and I find it to amount to 2,523,000,000 cubic feet. I add to that the upland water, which entered the river during the seven hours between high and low water, which I find amounted to 61,900,000 (I do not take the small figures), giving me a total of 2,585,000,000 cubic feet as having passed. The sewage discharged in one tide amounts to 9,894,000, being half a day's discharge, and that bears a ratio of 1 to 261 as compared with the river water.

13,856. (*Mr. Lumley Smith.*) Would you kindly tell me how you got your calculation of the difference between high and low water mark?—The mode of obtaining that was by calculating the volumes contained between the high and low water space for each successive length of the river starting from Teddington and going down to Crossness, a work involving some thousands of figures, but which has been done with accuracy.

13,857. (*Chairman.*) Let me see if I understand you; the water in the river at high water is of a certain height, at low water it is of a different height, the quantity of water between those two heights must have gone away?—That is so, *plus* that poured into it from other sources, which has also passed through it.

13,858. I do not see the "*plus*" so very plainly?—If I have a cistern, and I lower the water in that cistern three feet, I take out three feet of water; but if I have poured in a foot during that time, I must have taken out four feet, although lowering it only three feet.

13,859. Except that there is this difficulty, that you will have the tide running up in one part of the river while it is running down in another. How you make it as 1 to 260 as the amount of sewage to water, and Dr. Tidy says 20 times as much is sufficient for purification?—That is rather too rapid a calculation; you have to bear in mind that Dr. Tidy said that you are pouring it into water already contaminated with sewage.

13,860. That is the question I am going to ask you—otherwise, if it were one discharge of sewage only, it would go into 260 times its volume of water?—Yes, or 13 times as much as Dr. Tidy seemed to think was necessary.

13,861. (*Mr. Lumley Smith.*) You have the diagram there, would you supply us with a copy of that; that would show us the number of divisions into which the river has been divided for the purpose of giving the level at each point?—No, it would not show you that entirely; you will have an opportunity of asking me that in cross-examination. It is precisely the same operation as Mr. Mansergh carried out to give the quantity of water discharged from an isochronous line. It is the same principle, only Mr. Mansergh took the high water at Southend and I took it at Crossness, because that is the point which affects this inquiry.

13,862. You would have no objection to let us have a tracing of it?—Not the slightest, the tide has been divided into ten parts for other purposes. Now if we divide 261 by 20, then we get 13, and it therefore results that unless the river contains 12 days of unaltered sewage it would be competent to purify the sewage.

13,863. (*Chairman.*) 12 tides, would it not be?—Yes, 12 tides it should be. Then Mr. Mansergh told us, in the table which I referred to before, that on the 14th of September the percentage of sewage contained in the river at high water at Crossness was 6·4 per cent. of the whole volume, and at low water 8·7 per cent. I am taking the figures in column 11 of Table M3*a*. But now referring to Dr. Frankland's Table 9, which gives the actual chemical composition of the water in the river at North Woolwich immediately above the sewage outfalls on that day, I find it there stated that the organic carbon was ·366 in 100,000 parts, and at low water ·34, while the nitrogen was ·123 at high water, and at low water ·121. Now comparing that with the filtered water delivered by the water companies for drinking purposes in London, the water here is nearly as pure.

13,864. At what spot do you say?—At North Woolwich, the division immediately above the sewage outfalls, that is to say, the water which is going to pass down to receive the sewage. I take that division, because that is the water just going into the sewage. If I had gone up above, it would have been purer; but I speak of the water which is immediately going to receive the sewage.

13,865. (*Sir John Coode.*) What was the condition of the tide at this time?—I have taken high and low water. At high water it is ·366 of carbon, and at low water ·34, there being a difference of only one and half hundredth. Now referring to the analysis of the water as published every month by Mr. Crookes, Dr. Odling, and Dr. Tidy, furnished to the President of the Local Government Board, I find that upon the 7th December the Southwark and Vauxhall Company delivered water containing ·37 of carbon, or a little more.

13,866. (*Chairman.*) What have we to do with what water the people are drinking?—I am going to show that of this description of water you will have 260 times the bulk instead of 20 times the bulk diluting the sewage.

13,867. But did they say that it was always as pure as that at North Woolwich?—It is upon this day that they say the water is more impure than on any other of those taken, in consequence of there being only two-thirds of the flow at Teddington of the average flow during the whole year, so I purposely took the day upon which the Thames was alleged to be most impure. Upon the 30th of November it only contained 2·78 of sewage to the whole volume, as against 8·7 on the 14th September. I have therefore taken it when they say the river was in its worst state only containing two-thirds of the average upland flow, and upon that day we find the water at North Woolwich, nearly as pure as the drinking water supplied to the inhabitants of London, and therefore capable of purifying the sewage which was delivered to it in the proportion of $\frac{1}{260}$th part of its bulk.

13,868. Do I understand you to say that people might drink with impunity, and possibly without disgust, the water at North Woolwich upon that day?—Yes, at low water certainly; at high water it would have been a little salter.

13,869. At what state of the tide was that, was it when the tides were taking off, diminishing towards the neaps, do you know?—It was a day or two after the spring tides—when the tides were falling off a little.

13,870. That is the time when, according to the evidence, the overflow is greater than the inflow. What they say—and it is obviously true—is that when the tides are taking off, the sewage does not come back so high up the river as it does when the tides are making; indeed, I do not know that it would come up at all?—Some of the latter part would—that discharged towards the half ebb.

13,871. When the tides are taking off, it does not come up the river so high as when they are making?—That is so.

(*Mr. Lumley Smith.*) Simply as relates from tide to tide, it always is oscillating up and down.

(*Chairman to Mr. Lumley Smith.*) The truth of your float experiments was admitted to a certain extent—it was admitted that a float put in at Crossness would, when the tides were making, be higher up at the same state of the return tide than it was when it was put in, and that when the tides were

taking off, it would be lower down; do you know what the tides were doing then.

(*Witness.*) The tides were taking off, it was in fact just about an average but I take their own valuation of the sewage according to their own test and their own statement.

13,872. (*Mr. Lumley Smith.*) You are still taking the 14th of September?—I am still taking the 14th of September, and the river is stated then to be more than twice as impure as it was upon the 30th day of November. Mr. Baldwin Latham has given us three comparative tables, the 14th and the 22nd days of September, and the 30th day of November. Upon the 14th the flow over Teddington Weir was in round numbers about 80,000 cubic feet a minute, and then the river was most impure.

13,873. (*Chairman.*) This appears to me to be a mistification of some sort or other, for your own witnesses, if I may say so, that is to say the medical men from Woolwich, say, that when they cross the river the stench is most offensive occasionally—according to your account it ought not to be, in fact, you say that it is not, and almost that it ought to be drinkable?—It is the only evidence we have got so far—it is evidence put in by the other side.

13,874. It is unintelligible to me, because your own witnesses sometimes describe it as something that is positively loathsome when they are crossing in a steamer, whereas you say that it ought to be drinkable?—The river water at Woolwich, as far as my experience goes, is never in a stinking state.

(*Mr. Norman Bazalgette.*) With all deference to your Lordship, I do not think our witnesses said that that was the rule, but they said that on certain exceptional occasions they had smelt it.

(*Chairman.*) They did not say that was the rule—they said it was free from smell in the winter, but what I understand from Mr. Law is, that according to the evidence given upon the other side, it never could be a stinking river.

(*Witness.*) There are so many other stinks in that neighbourhood, it must be remembered, that it is very difficult indeed to say that; but I would venture to ask your Lordship to keep your mind perfectly open upon that point until you have some personal experience. I think that would be far more satisfactory to your Lordship.

(*Chairman.*) I quite think so too.

(*Witness.*) Therefore the result at which I arrive is simply this: that if you take 20 parts of pure water as delivered by the Southwark and Vauxhall Company, and mix that with one volume of sewage, because certainly that is pure enough to purify it, the mixture would often be less pure or less diluted than when mixed with the 261 parts of Woolwich water with which the sewage really is diluted at the time of its discharge.

13,875. (*Mr. Lumley Smith.*) That I understand, if I might ask, is based on Dr. Frankland's tables entirely?—Yes, upon Dr. Frankland's Table 9. I then pass on to the amount of oxygen. I would call your attention to question 12,289, which was put by Dr. Stevenson to Professor Way, he is asked: "Then "there is the mineral matter in the urine, which is about one fifth"; and he says, "Yes, that is a good "deal. I do not wish to overrate the matter. I will "put it in this way: If I take the fæces alone and "say that 100 tons of oxygen are wanted, it is an "enormous quantity to be obtained to bring to the "surface of the river to be changed for something "else; and my belief is that if it were possible that "the whole of the sewage should be burnt up day "by day as it went in, the air of the neighbourhood "would be irrespirable; all the oxygen would be "gone." That, of course, from Professor Way requires great consideration. I have therefore made this calculation. The sewage admittedly travels 12 miles, sometimes 15 miles, in its passage down the river, and it travels at least 11 miles back, at Spring tides it comes up the whole 12 again.

13,876. (*Mr. Abernethy.*) I may take it for granted that it all passes down, that no part is deposited?—The part deposited could not be oxidised by the atmosphere. Now the mean superficial area of the river 12 miles below Barking, that is to say, the mean between high and low water, is 151,000,000 square feet, and each cubic foot of air contains 123 grains of oxygen, so that a layer of air only one foot thick would contain 1,189 tons of oxygen; and then, taking the 11 miles back, the superficial area would be 138,000,000 cubic feet of air, which at the same rate would contain 1093 tons of oxygen, making altogether 2,282 tons of oxygen, or 46 times the quantity required; and if it did not take up the oxygen for more than a foot, it would not affect the atmosphere of the people breathing it in the neighbourhood. That only shows how very dangerous a thing it is to make random statements without making a calculation.

13,877. (*Chairman.*) Is it supposed that it is the atmospheric air which oxidises the sewage?—No, but it has this very important influence; if I have water containing its full quantity of oxygen, that is 2 cubic inches to the gallon, it will not absorb any more. If I, from any cause, deprive it of half its normal quantity, it sucks it in from the air with avidity, just as a sponge does water. Now if I take the oxygen of the water into which the sewage is discharged, a cubic inch of oxygen weighs ·3438 of a grain. Then if one gallon of tidal water at the outfalls contains an inch of oxygen, and, referring to the tables of analysis, we find it contains upon the average at least an inch, we shall have 354 tons of oxygen in the water itself, or seven times the quantity required before it has to take any from the air; and that is in the diminished condition of the water as it approaches the outfalls. Then what do we find, if we find the water as it approaches the outfalls has one inch to the gallon of oxygen, and if we examine it when it reaches Erith and find it only has ·42 of an inch, the inference is that the balance has been used in burning up the sewage, the deficiency proving that it has done its work.

13,878. I thought it was alleged upon your side that the unscientific fishes would die in spite of the oxygen?—That is precisely what happens, it is the oxygen being taken out of the water to purify the sewage which prevents the fish living. One thing or the other must happen, either the oxygen must be taken to purify the sewage, or it is not; if it is not, the fish would live and the human beings would suffer, but the fact is the reverse—the fishes suffer and the human beings do not.

13,879. (*Sir John Coode.*) When you take the quantity of oxygen in the air a foot above the surface, you only use that as an illustration, you do not put that as a fixed quantity?—No, the air is always being changed by winds and otherwise.

13,880. (*Mr. Norman Bazalgette.*) You have given some attention to the subject of deposits in the river, have you not?—I have.

13,881. What do you say to them?—I say, first of all, the Thames must be a muddy river, no river under the condition of the Thames can be other than a muddy river. When, in Queen Elizabeth's time, it was devoted to swans and pleasure barges, it might have been a clean one, but with the enormous commerce carried on upon it, and the changes which have been made in it since then, it must be a muddy river.

13,882. (*Chairman.*) You mean in the region of the metropolis?—I do; I mean as high up as Westminster Bridge, where the traffic is so large and the water kept in such continued agitation, that it is impossible for it to settle, and it is therefore always in a muddy state more or less, varying considerably. Now I would first refer to Dr. Frankland's Report, because Dr. Frankland attributes the mud in a very large measure to the sewage outfalls. He put in a report, with copious tables at the end, which showed that there were upwards of 1,000,000 tons of sewage poured into the river through the outfalls every year. The first observation I would make with regard to this report is this——

*Mr. H. Law.*

30 May 1883.

13,883. Do you say 1,000,000 tons of solid matter?—Yes, of suspended solid matter. The first remark I would make is that these tables have not been prepared with sufficient care to warrant their receiving much consideration. Table B, which purports to give the quantity of suspended matter contained in the sewage according to the heaviness of the rainfall (those quantities being derived from various authorities) I find contains errors. For instance, in Table B, at page 18, I find that the discharge from the Savoy Street sewer upon the 11th of June is taken twice over, and therefore affects the average.

13,884. (*Sir John Coode.*) Our attention was called to that?—Yes, but I am calling attention to that to show the bearing it has upon this table, and the value of the results at which they arrive. Then I find it stated on that day "very slight rain, not measurable" but on referring to the actual authority, so far from its being a very slight rain, and not measurable, I find that upon the day before, in six hours preceding midnight, $\frac{3}{100}$ths of an inch fell, and from midnight to noon of the day itself $\frac{65}{1000}$ths, and that consequently $\frac{15}{100}$ths of rain fell in 18 hours, which was very nearly the maximum provided for in the sewers of Sir Joseph Bazalgette, if the storm overflows were not to come into play. Therefore it was a very heavy rain indeed, and not so slight a one as not to be measurable; that of course affects the way in which these quantities are to be dealt with. Then I find, again, Messrs. Hofmann and Witt are quoted as being an authority for the discharge of 209 grains to the gallon of matter discharged from the Savoy Street sewer upon the 20th June, but I can find no such figure at all in Messrs. Hofmann and Witt's Report.

13,885. (*Chairman.*) Was this an overflow discharge?—No, this was from the sewers.

13,886. Into an intercepting sewer?—No, this was before the intercepting sewers were made; this was in 1857. And then, also, I may say that the value of these tables is quite destroyed, owing to the fact that when these observations were taken in 1857, the sewers were in a totally different conditions from what they are now, and that the catch pits, and the system of preventing mud from going down into the sewers, was not adopted then as it is now.

13,887. Dr. Frankland, I think you say, says that the sewers discharge 1,000,000 tons per annum of solid matter; what do you say it ought to, I want to ascertain that?—I have not gone into that.

13,888. You merely say they are wrong?—Yes.

13,889. Because I dare say Mr. Lumley Smith would give you 10 per cent. rather than fight it in detail?—No doubt, but I am coming now to a much more important point. The principle upon which these tables are calculated is, as I said yesterday, that Dr. Frankland assumes that $\frac{4}{5}$ths of every drop of rain which falls, however slight the fall may be, goes into the sewer. I did not exaggerate when I said that, because what do I find when I turn to the table? He says there were 191 days in the year when there was no rainfall, and when there were 131,000,000 gallons of sewage discharged in the 24 hours, each of those gallons containing 23 grains of solid matter. In that I concur. But his next step is this; he says that upon 32 days $\frac{1}{100}$ths of an inch of rain (which is the thickness of a sheet of paper) fell in 24 hours, and he deliberately states that the effect of that rainfall, amounting to the thickness of a sheet of paper, was to increase the flow of the sewage at Barking by 14,000,000 gallons. Now I say not a particle of it could have reached there. Then he says that it had the further effect of increasing the proportion of solid deposit in every gallon from 23 to 42·9, and upon those data this table is calculated.

13,890. (*Mr. Lumley Smith.*) Have you the reference to his answer?—No, it is from his table, which speaks for itself. Now that is an incredible statement, of course, because it requires a great deal more rain than that ever to reach the sewers. A shower of rain which in 24 hours would only amount, if the surface were perfectly impervious, to a depth of $\frac{1}{100}$th of an inch, could never reach the sewers; if it were to travel over any surface it would be dissipated by evaporation, it certainly never could travel and carry double the quantity of solid matter with it. Having made that observation to show that the sewers do not contribute the enormous quantity which Dr. Frankland supposes, I now proceed to examine what are the sources from which the mud really is derived, and I would refer to an answer given by Captain Burstal, in his evidence before the Rivers Pollution Commission, when he was asked, "Was the Thames ever a very bright stream?" and his answer was this, "If you mean pellucid, I should think not, "but there is no doubt about this, that it was far "cleaner before steamers were invented than it has "been since; it is the steamers that stir the shore "up. If you go down the river and watch the action "of a wave made by a paddle wheel steamer, it is "something frightful; it will tear away masses as "large as this table from the saltings, and the rebound "mashes the muddy portions up, at least, it mixes up "the muddy portions with the water, and makes the "water turbid." That answer was given in the year 1866, since then the number of steamers has more than doubled, and the tonnage has more than trebled, and screw steamers are almost universal now.

13,891. (*Chairman.*) Do let me understand this; does Dr. Frankland or anybody else say that all the mud in the river comes from the sewers?—The case as it is put upon the other side is——

13,892. But does he say so?—Yes.

13,893. Does Dr. Frankland really say so?—Not Dr. Frankland, but Mr. Leach.

13,894. Then we know of our own knowledge that it is not true?—It has been stated on the other side that the deposits which have taken place at Erith are, in consequence of the mud, discharged from the outfall.

13,895. That is a different thing; it is one thing to say that all the mud in the river is produced by the sewers, but it is quite another thing to say that the mud at any particular spot has been very much augmented by the sewers?—Extraordinary as that assertion is, it was made by Mr. Leach upon the Mud Inquiry, and can be found for the Commission to refer to.

13,896. There can be no doubt that if it was made, it was wrong; but at all events it has not been made here.

(*Witness.*) But the importance of it is, that we are made in great measure responsible for the muddy and filthy state of the river, whereas if you analyse the mud, you will find the mud washed from the banks contains nearly as much polluting matter as the mud from the sewage.

13,897. (*Mr. Abernethy.*) That is to say, if you take the mud from the saltings, you will find them of very much the same character as you would find the mud opposite Crossness?—Yes, just so.

13,898. (*Chairman.*) If you were to take a spade full of the mud from a bank which has not been disturbed, which is as nature put it, if I may use the expression, would you find noxious matter in it?—Yes, it would be nearly identical in its composition with the mud found in the bottom of the river; that has been carefully analysed by the chemists. Now, I was observing that screw steamers stir up the mud more than the paddles, because the screw is nearer to the keel, and the motion goes deeper; and it is not the swell caused by the paddles only, but it is the great wave which is raised by the bows of the vessel, it is the increasing size and speed of the vessels now in use which has that effect upon the banks.

13,899. (*Sir John Coode.*) Is that disputed by anybody?—I think you will find that Captain Burstal spoke of the paddle steamers having had an effect upon the banks; that was put to him. There is another circumstance which also causes the effect produced by steamers now to be very much greater than it was formerly, and that is the increased height to which the tide rises; it therefore affects the banks

further up and overflows the saltings higher up; it soddens them and disposes them to be washed away.

13,900. (*Chairman.*) Does the tide rise higher up below London Bridge than it used formerly to do?—Considerably; it rises two feet higher since the removal of old London Bridge and the dredging of the river.

13,901. I should have thought the removal of London Bridge would have diminished the height of the tide below, whereas you say it has not?—No, on the contrary; a certain amount of tidal force is delivered at the mouth of the river, and that is destroyed in two ways, first, by the friction it meets arising from shoals or bridges, and the rest is exhausted by heaping up the water against gravity, so that the water rises very much higher at the top of an estuary than at the mouth. In the bay of Fundy the difference is as much as 120 feet. If you take away the shoals, and so reduce the friction, the force has then to be exhausted by heaping up the water at the upper end.

13,902. I can understand that the removal of London Bridge would cause the tide to rise a good deal higher at Teddington or at Richmond; but I should have thought that it would have tended to reduce the tide at the lower part of the river?—That is so, as far as it goes, but it is the removal of the shoals lower down the river which affects the lower part of the river. The removal of London Bridge principally affected the part above London Bridge. The question and answer have now been found in which Captain Burstal suggested that the paddle steamers produced a greater action upon the banks than the screw steamers, but I do not think it is worth while to pursue that. Now, not only have you the banks below being disturbed, but you have the banks above bridge which are being seriously diminished by the steam launches. In 1880 I spent a week in examining the banks of the river from Kingston to Oxford, and I found that throughout the whole length of the river the banks were being rapidly washed away. The Conservators have not the funds at their disposal to enable them to take protective measures to prevent the banks being washed away.

13,903. (*Prof. Williamson.*) What led you to the conclusion that they were breaking away?—I saw them cracked, and breaking down with the grass upon the top of them.

13,904. But you said they had been washed away?—If you have upon a river of that character a perfectly perpendicular bank with a sharp edge and pieces gone here and there, an engineer knows in a moment whether the bank of a river is breaking down, or whether it is in its natural state. I think that if the Commission were to refer to the reports made monthly by Colonel Bolton, they would find there a statement made as to the large quantity of detritus which is brought down.

13,905. (*Sir John Coode.*) Now you are speaking of the quantity brought down from above?—Yes, I am speaking of the quantity brought over Teddington Weir. In January he reported,—"The river was "again in a state of flood through the month, and "was much polluted by the effluent waters bringing "down from the land quantities of marl and clay, "as well as decayed vegetation and other impurities, "which stained the water and rendered it exceedingly "turbid." And in the 6th Report of the Rivers Pollution Commission, in investigating the metropolitan water supply, they give at page 269, as a specimen of the influence which the quantity of rain has upon the amount of deposit it contains, one page from the book kept by the West Middlesex Water Company.

13,906. (*Chairman.*) I should think the Commission are satisfied that the greater portion of the mud in the river does not come from the mud in the sewers but comes from the abrasion of the banks and from other sources?—I am happy to hear your Lordship say so, because the very reverse was contended in the other inquiry.

(*Mr. Abernethy.*) It was contended that there were certain banks which were composed of sewage mud.

(*Chairman.*) But one remembers the time when there were no sewers ran into the river at all, and there was a quantity of mud then, and one remembers a time when there were no steamers upon the river, and the mud lay upon the banks, and that after the introduction of steamers the banks were, in places, washed clean, but the mud is still there in certain parts.

(*Witness.*) What I am coming to is this, that if you were to shut out the sewage to-morrow, you would not make any tangible difference in the quantity of mud deposited upon those mud banks; and I am going to show the reason why mud banks were formed in those particular places, that it is not in consequence of their proximity to the sewage outfalls, but in consequence of other conditions which the engineers will entirely appreciate, and I am coming to them immediately.

13,907. (*Chairman.*) That is coming to the point?—This (*producing Plan No.* 19; *see Appendix AE.*) is a plan of one of the large saltings in the river. I have had this made to show the manner in which the banks break down; these saltings break down in all directions.

13,908. (*Sir John Coode.*) Where is Broadness, to which this refers?—It is near Gravesend. I would merely mention that the total length of bank upon the two sides of the river, at least upon the southern side from Kingston to All Hallows, and upon the north side from Teddington to Yantlett, is 133 miles, of which 43 miles, when I had the surveys made in 1879, were unprotected, and little has been done in the way of protection since. So that the extent of this washing away may be understood, more especially when I mention the rivulets which intersect them in all directions, and which therefore expose a very much larger surface than the mere shore line of the river.

13,909. That mileage you have just given us is measuring round the irregularities, is it?—No, only measuring round the coast-line. Then I would call attention briefly to Diagram 34 (*see Appendix BM.*), which is really plotted from observations which were taken jointly by Mr. Keats and Dr. Tidy at the close of the subsequent inquiry. Observations were made at Teddington for a month of the quantity of water flowing over the weir, and of the quantity of suspended matter contained in the water; and it was shown by the diagram that, whereas upon the 7th February, when there was no rain, the amount of suspended matter per gallon was only ·18, only five or six tons came over altogether. On the 21st, at a time of rain, the quantity of water increased by six times, and the quantity of suspended matter per gallon rose to 24 grains, so that the quantity of suspended matter which came over upon that day was 4,666 tons, as compared with six tons upon the previous day I have given.

13,910. Was that over Teddington Weir in one day?—Yes, over Teddington Weir in one day; and those are the joint results of the observations of the chemists on both sides, Mr. Keates and Dr. Tidy,—to settle in fact a disputed point. The observations were made conjointly.

13,911. And they agreed upon that view?—They agreed upon that view. The table is contained in the Mud Report, which I believe is before the Commission. Now my next proposition is one which I am sure will be assented to, that in a river so laden with mud, if you have slack water, mud must be deposited. I have here the sections which were just referred to, taken by Telford above London Bridge in 1823, and by Captain Shields below London Bridge in 1796, to compare with those that were taken by myself in 1843 (*shewing the sections*), and upon those I have coloured the deepening of the water blue, and the shoaling of the water red; and it is very striking how all the sections above London Bridge are blue, the river having scoured itself; but all the sections below London Bridge are red, showing the deposit which had taken place before 1843 in the 20 years.

*Mr. H. Law.*

30 May 1883.

13,912. (*Chairman.*) Will you explain that a little further?—Upon each of these sections there are two lines representing the bed of the river; the upper line is the river as found by Telford in 1823, and the lower line is the river as found by myself in 1843, deepened, therefore, to the extent of the blue colour.

13,913. (*Sir John Coode.*) What is the vertical scale of that section?—The vertical scale is 20 feet to the inch.

13,914. Do those two sheets refer to the same section of the river at different times, or are they continuous all the way down?—The sections commence at Vauxhall Bridge—on one sheet they extend to London Bridge—upon the next sheet they extend from London Bridge to Blackwall Point; and they show that owing to the removal of London Bridge the river began to deepen itself from natural causes; the diagram at the junction of the two sheets shows from Fishmonger's Hall to Hibernia Wharf; and here you have it remarkably clearly shown that the natural action of the river is, owing to the acceleration of the current by the removal of London Bridge, to scour away the material above and to deposit it in the Pool. In some places you will see enormous deposits. I have for convenience mounted them upon one sheet but they are all to be found in the first report of the Metropolis Improvements Commission, of which a copy will be supplied to the Commission.

13,915. (*Chairman.*) Are the reds deposits?—Yes, the reds are deposits, the blue being deepenings. The value of this diagram is to show what was taking place long before either the Thames Embankment was constructed or the interception of the sewers. I beg to hand in the Report from which they are taken.

13,916. (*Sir John Coode.*) The last date is 1843, and the first date is what?—The first date above London Bridge, is 1823 and below London Bridge is 1796.

13,917. (*Mr. Lumley Smith.*) And what is your furthest point to which you go?—Blackwall Point. There is one other diagram to which I wish to call your attention, and which is very important.

13,918. (*Sir John Coode.*) Are you sure that you have got the same standard of low water that you had in the year 1796?—Yes. I was very careful about that. I had the wharves in a sufficient number of places where they had not been altered, to give me bench marks at frequent intervals.

13,919. And the levels of the earliest date you have ascertained?—They were shown. The wharf wall was upon one section, and I was able by comparing the wharf walls upon different sections to ascertain their identity.

13,920. (*Mr. Abernethy.*) I suppose those sections show that if you enlarge the sectional area in any part of the river, shoals rise up?—No, these are to show that from natural causes the Thames was scouring above London Bridge and depositing below London Bridge.

13,921. But the removal of London Bridge was not a natural cause; that was a physical operation?—But after that physical operation, the banks above London Bridge were scoured out and deposited in the Pool owing to the insufficiency of the current to carry the solid matter further onwards. Now this *Diagram No.* 18 (*see Appendix BL.*) shows that the level of the marshes inside the sea wall, as it is termed, or bank, and which has been made for the protection of those marshes, is on this particular section, 5 feet lower than the level of the saltings outside; and that therefore shows with absolute certainty that since the sea wall was built the river has deposited sufficiently to raise its surface by 5 feet, that the deposit which has been going on for a very long period, imperceptibly almost, has gradually raised the level of those thousands of acres outside the sea wall to a height of 5 feet, and that was confirmed by what was found in sinking the shaft for the Thames Tunnel upon the Wapping side, where we cut in half a line of old wharf, about 70 feet within the then existing line, and with the top of it 5 feet lower than the then level of the surface of the ground. In fact, we have proof all the way down the river that the river, as many, and, indeed, almost all rivers do, has been raising its bed. Now I have here (*shewing some charts*) two Admiralty charts of the same part, namely, the mouth of the river, as published in 1856 and as published at the present time, and I have prepared four sections at points upon the plan which will be laid before the Commission. (*Diagram No.* 35; *see Appendix AZ.*)

13,922. (*Chairman.*) Your object now, as I understand, is to show that deposits have taken place and elevations of parts of the bed of the river?—My object is, and I have now just finished this part of my examination, to show you the extent to which these changes take place—the enormous magnitude of the deposits which are taking place—and that therefore anything which might come from the sewers would in no way affect it generally, and then I am going to show you the local cause of the banks which exist in the immediate neighbourhood of the outfall.

13,923. I cannot help thinking that the latter part is the relevant matter?—I have just finished this part of the case. This is the last fact that I am bringing before your notice, and the effect of it is to show that at the mouth of the river itself considerable silting is taking place. By a comparison of the shore lines, you will find that while the high water line is being washed away, the low water line is being extended out into the river to the extent of 1,000 yards at the mouth of the Thames.

(*Sir John Coode.*) The term "mouth of the Thames" is a little vague—would you kindly tell us the particular part of the section you are referring to.

(*Chairman to Mr. Lumley Smith.*) You will not dispute, I presume, that there have been raisings of part of the bed of the river.

(*Mr. Lumley Smith.*) I believe that is the fact, no doubt.

(*Witness.*) Within the last week only, three acres of a cliff, 70 feet in height, in the Isle of Sheppey, have been washed away, carrying away a churchyard into the river.

13,924. (*Mr. Abernethy.*) That was a land slip?—Yes, carrying the land of a churchyard into the river, the church having been previously removed. Then I would wish now to point out that many of the changes, and the very banks that are now spoken of, have arisen to a great extent from artificial dredging carried on at those points, that up to the year 1858 when the Conservators were appointed, the only dredging which took place in the river Thames was that upon the part of the Trinity Corporation, who simply dredged for gravel where it was suitable for ballast, for the purpose of selling it.

13,925. (*Sir John Coode.*) And for no other purpose?—For no other purpose; and it was not until the Conservators were appointed under Act of Parliament, that they provided themselves with extremely powerful dredging machines, and resorted to the use of gunpowder to break up iron bound gravels which had existed in the bed of the river, forming shoals, or "shelves," as they were called, such as Barking Shelf, Ham Shelf, and Erith Shelf. Those various shoals or shelves extended out principally from the northern side, and drove the current over to the southern side. A very great improvement was effected, as far as the navigation was concerned, by the removal of those shoals; but the result was to enlarge the section of the river to such an extent that the velocity became diminished, and a deposit took place in those parts of the river where the current having been diverted over to where the channel had been dredged the other side of the channel was left in an eddy and in still water. I am now going to show the commencement of the formation of the shoals in the neighbourhood of the outfalls previously to the outfalls being put there, which I think is a very important point. The plan which will be now laid before your Lordship will

show the position of certain sections which I took (*Diagram No. 6 handed in; see Appendix B.A.*) This is the plan of the river from just below Woolwich to near Erith, and it comprises Barking Reach and Halfway Reach, in which the two sewage outfalls are situated. The northern outfall your Lordship will see at the right hand corner, and the southern outfall about nearly over the word "Kent" on the southern side. The dotted lines across show the lines of sections which will now be handed to your Lordship, and those sections show a comparison of the soundings taken in 1833 by Captain Bullock and Captain Burstall jointly, with those taken in 1861 by the Conservators and in 1864 by the Surveyor to the Board of Works, Mr. McDougal; and beneath you have the section of 1861 compared with that of 1864. (*Diagrams Nos. 7 to 13 were handed in; see Appendices BB. 1 to 7.*) There is a series of sections given upon the several lines, and from those you will see that owing to the removal of the shoals, as shown by the red colour, the accumulations commenced as shown by the brown; and I will put in a table which gives the sectional area of the river on these several lines in 1861, and the mean velocity of the stream at half ebb, as compared with the sectional area and velocity in 1864, if there had been no deposit, and as compared with that which was actually the case in 1864 after the deposit had taken place. I will take one case as an illustration—taking the line A A., the sectional area at half ebb in 1861 was 42,990 square feet, and the mean velocity through that section was 176 feet, that was sufficient to keep it clean. By the dredging which took place in 1864, if no deposit had taken place, there would have been a sectional area of 46,670 as against 42,990. The velocity being reduced to 162 instead of 176, it could no longer keep itself clean, and it deposited mud upon the southern side where the stream was not so strong, and reduced itself to a sectional area of 45,710 increasing the velocity to 165, which, although 11 feet less than it had previously been, was of course quicker than it would have been if no deposit had taken place, and as this dredging has gone on so has the deposit gone on. But the simple object of these sections is to show you that the dredging having commenced previously to the construction of the outfalls, so the deposit also had commenced upon the lines of these very banks. A careful examination of these sections will show that where dredging was, deposit take place, and that the deposit was the nucleus or commencement of the banks of which complaint is now made.

*Table 9 was handed in, and is as follows:*

TABLE 9.

COMPARISON of the VELOCITIES of the EBB STREAM at HALF EBB of an AVERAGE TIDE in 1861 and in 1864, in feet per minute.

| Locality; reference to Drawing L and C, No. 6. | Actual in 1861. | | In 1864, if there had been no Deposit. | | Actual in 1864. | |
|---|---|---|---|---|---|---|
| | Sectional area in square feet. | Mean Velocity. | Sectional area in square feet. | Mean Velocity. | Sectional area in square feet. | Mean Velocity. |
| Line A.A. - | 42,990 | 176 | 46,670 | 162 | 45,710 | 165 |
| „ B.B. - | 50,812 | 159 | 55,850 | 144 | 52,895 | 152 |
| „ C.C. | 51,030 | 170 | 56,670 | 153 | 54,200 | 160 |
| „ D.D. - | 54,670 | 163 | 57,610 | 154 | 49,560 | 179 |
| „ E.E. - | 54,185 | 158 | 58,060 | 154 | 53,700 | 167 |
| „ F.F. - | 47,780 | 191 | 54,190 | 168 | 52,600 | 173 |

13,926. (*Chairman.*) Your theory is, area of river increased, velocity of water therefore diminished, and, consequently, greater capacity for deposit?—Yes, and something more than that; that the diversion of the current owing to the form of the river upon the plan left certain parts in slack water, and caused a deposit to take place in these places. Plan No. 5 (*handing in the same; see Appendix BC.*) is a plan of the river from Jenningtree Point to Crayfordness, comprising the two parts of the river called Erith Reach and Erith Rands, and the brown spots upon the plan are spots where mud was shown to exist by the Conservators upon their plan made in 1861, and therefore it will show upon their own evidence what was the state of the river as regards the muddy bottom at that date.

13,927. (*Mr. Abernethy.*) That comes back to the other proposition of a short time ago, that if by dredging or other operations you alter the direction and the velocity of the mean current, shoals will form in other parts of the river?—Yes, but the object of this plan is to show that mud existed in the very parts of the river in 1861 where mud is found to-day.

(*Mr. Abernethy.*) There is no doubt about it.

(*Witness.*) I now put in four plans of the same part of the river, Nos. 1 to 4, coloured so as to show the depth of water. (*The same were handed in; see Appendices BD. 1 to 4.*) Plans 1 to 4 are plans showing the form and depth of channel in 1831 from the soundings of Captain Bullock; in 1861 from the soundings of the Conservators; in 1879 from the soundings of the Conservators; and in 1882 from soundings taken by ourselves. In order to show graphically the change in the river and the depth, the colour is proportional to the depth of water. If, therefore, your Lordship will compare plan No. 1 with plan No. 2, you will see that between those two years the shoal which extended out from Great Cold Harbour Point, which is called Erith Shelf, had been nearly removed. In 1833, when that shelf existed, and also Erith Rands, which is the white patch below Erith in the middle of the river, the current was diverted upon the southern side; and near where you see a dark patch just opposite Rainham, vessels used to lie, and higher up there was a berth for colliers going up the river. Subsequently, if you compare 1833 with 1882, you will see that the deep channel now is upon the northern side. I shall show you from actual observation that the run of the tide is upon the northern side, and that the south side, where the deposit is now taking place, is left in slack water. I have one small table which I would put in, being merely a resumé of the contents of the small plan No. 20; *see Appendix BE.*) (to which I need hardly refer you) upon a small scale of this part of the river. The river has been divided into 8 sections, and the cubic contents of those sections has been calculated, and it shows that the increase in the cubic content of the water since 1833 has averaged about 23 per cent., and that the increase since 1861 has been nearly 3 per cent., and that the increase since 1879 has been nearly 2 per cent., and that increase is still going on, notwithstanding that deposit.

*Table 10 was handed in, and was as follows:*

TABLE 10.

TABULAR STATEMENT showing the Low-water Capacity of Divisions 2, 3, and 4 of the River Thames, derived from the Soundings of 1833, 1861, 1879, and 1882.

| Date. | Total of Divisions 2, 3, and 4. | | | Percentage of Increase of Total Contents of Channel. | | |
|---|---|---|---|---|---|---|
| | North. | South. | Grand Total. | Since 1833. | Since 1861. | Since 1879. |
| 1833 | 6,109,391 | 7,369,015 | 13,478,406 | | | |
| 1861 | 7,893,584 | 8,568,987 | 16,462,571 | 22·14 | .. | .. |
| 1879 | 7,889,159 | 8,704,320 | 16,593,479 | 23·11 | 0·80 | .. |
| 1882 | 8,123,542 | 8,771,689 | 16,895,231 | 25·35 | 2·63 | 1·82 |

*Mr. H. Law.*
30 May 1883.

13,928. (*Sir John Coode.*) Will you refer us to the various percentages of increase, because some of the plans do not stretch over quite the same area of the river?—We were driven last winter from our soundings and observations by stress of weather, but I would refer you to plan No. 20.

13,929. (*Sir John Coode.*) All these percentages of increase, if I understand Plan No. 20, are between Jenningtree Point and Crayfordness?—No, they only comprise Divisions Nos. 2, 3, and 4, because we were prevented by stress of weather from taking Division No. 1. Table 10. explains it.

13,930. (*Mr. Norman Bazalgette.*) Up to 1879 they comprise all divisions?—Yes, they do up to 1879, but in 1882 we were taking them in the autumn, and the weather became so tempestuous that we were unable to complete them. Now, it will be within the recollection of the Commission that this longitudinal section of the river was put in by Mr. Mansergh, and that an arbitrary line, as I may call it, in blue was drawn from the river at Woolwich to the river in Long Reach, and then imagining that line to express properly the increased capacity which the river should have had, it showed that there were deposits at the points where the bed rose above the blue line, and that the deposit had been increasing at Crossness, and it was, therefore, said, inasmuch as the blue line represents what the river should have been, that had it not been for the outfalls, the deposit would not have taken place there. But the way in which I have examined that question is this: I have calculated the quantity of tidal water passing through each section the of river at half ebb, that being the time when average results would be obtained and the maximum velocity. I want to explain to the Commission the way in which I arrived at the quantity of water, because, of course, that is very important, and I now lay before you Diagram No. 21, which will explain the manner in which that quantity is arrived at (*Diagram No. 21 was handed in; see Appendix BF.*). I am sure the Commission will find I have not loaded them with papers, and that the diagrams are the shortest way in which I could have put the information before them, and that they will convey the best information. Diagram No. 21 is a longitudinal section of the River Thames, extending from Teddington to Gravesend, and the upper line of the blue tint there shows the level of the surface of the river at 7.10 in the morning, which was half an hour before the middle of the ebb tide at the sewage outfalls. The lower line represents the surface half an hour after half ebb. Now, pursuing the same system that we did before, and calculating the quantity of water contained in that band, together with the water coming over Teddington Weir and the different tributaries during that time, we get very accurately the quantity of water passing at any point during the middle hour of the ebb tide; and therefore we get the quantity of water passing per minute; and having the transverse sectional area we ascertain the mean velocity at each of those points. I will now put in a table which contains, first, the number of the section, the locality, the transverse sectional area in square feet, the quantity of water in cubic feet passing through the section per minute, the mean velocity of current in feet per minute, and the authority for the figures; the authorities being Mr. Shelford in 1877, Mr. Mansergh in 1878, the Metropolitan Board of Works in 1879, the Thames Conservators in 1879, and Mr. Law and Mr. Chatterton in 1879.

*Table* 11 *was handed in, and was as follows:—*

TABLE No. 11.

SHOWING the MEAN VELOCITIES of the CURRENT in the RIVER THAMES between BLACKWALL POINT and LONG REACH, during the Middle of the EBB TIDE, 3rd October 1882.

| No. of Section on Diagram No. 17. | Locality. | At Half Ebb. | | | Authority. |
|---|---|---|---|---|---|
| | | Transverse Sectional Area in Square Feet. | Quantity of Water in Cubic Feet passing through the Section per Minute. | Mean Velocity of Current in Feet per Minute. | |
| 1 | Blackwall Point | 26,187 | 5,101,490 | 195 | S. |
| 2 | " | 29,360 | 6,795,730 | 197 | " |
| 3 | Charlton Ballast Wharf | 32,120 | 5,881,040 | 183 | M. |
| 4 | " " | 32,770 | 6,223,435 | 190 | " |
| 5 | Charlton Pier | 34,720 | 6,391,190 | 184 | S. |
| 6 | Ham Creek | 35,710 | 6,545,500 | 183 | M. |
| 7 | North Woolwich | 31,320 | 6,848,960 | 219 | " |
| 8 | " | 33,995 | 7,006,845 | 206 | S. |
| 9 | Gallion Point | 36,035 | 7,150,225 | 198 | M. |
| 10 | Duval's House | 47,640 | 7,522,775 | 158 | " |
| 11 | " | 45,045 | 7,645,790 | 170 | M.B.W. |
| 12 | " | 44,050 | 7,679,190 | 174 | " |
| 13 | Margaret Ness | 39,605 | 7,850,280 | 198 | S. |
| 14 | Northern Outfall, Barking | 47,025 | 7,945,765 | 169 | M. |
| 15 | " | 47,315 | 8,029,270 | 170 | M.B.W. |
| 16 | Barking Creek | 47,795 | 8,281,990 | 173 | " |
| 17 | " | 39,565 | 8,341,520 | 211 | M. |
| 18 | False Point | 43,765 | 8,391,005 | 192 | M.B.W. |
| 19 | " | 45,830 | 8,533,535 | 186 | S. |
| 20 | " | 47,865 | 8,569,170 | 179 | M.B.W |
| 21 | " | 47,995 | 8,743,055 | 182 | M. |
| 22 | " | 49,925 | 8,809,950 | 177 | M.B.W. |
| 23 | " | 50,040 | 9,001,575 | 180 | " |
| 24 | Leather Bottle Point | 50,435 | 9,165,375 | 182 | M. |
| 25 | " " | 53,800 | 9,292,500 | 173 | M.B.W. |
| 26 | " " | 53,650 | 9,360,385 | 175 | M. |
| 27 | " " | 57,275 | 9,454,970 | 165 | M.B.W. |
| 28 | " " | 55,665 | 9,495,835 | 171 | M. |
| 29 | Southern Outfall, Crossness | 56,510 | 9,527,235 | 169 | M.B.W. |
| 30 | " " | 58,945 | 9,550,465 | 162 | " |
| 31 | " " | 55,410 | 9,587,430 | 173 | M. |
| 32 | " " | 47,005 | 9,684,460 | 206 | M.B.W. |
| 33 | " " | 50,380 | 9,711,040 | 193 | M. |
| 34 | " " | 48,090 | 9,785,855 | 204 | " |
| 35 | " " | 50,140 | 9,858,225 | 197 | M.B.W. |
| 36 | " " | 49,525 | 9,932,025 | 201 | M. |
| 37 | " " | 53,670 | 10,002,840 | 187 | " |
| 38 | Hornchurch Sluice | 52,245 | 10,105,175 | 193 | M.B.W. |
| 39 | " " | 54,435 | 10,220,175 | 188 | " |
| 40 | " " | 53,050 | 10,263,725 | 194 | " |
| 41 | " " | 58,240 | 10,364,785 | 178 | T.C. |
| 42 | Jenningtree Point | 53,490 | 10,396,171 | 194 | M. |
| 43 | " " | 53,885 | 10,425,840 | 194 | T.C. |
| 44 | " " | 54,965 | 10,486,925 | 191 | " |
| 45 | " " | 55,695 | 10,521,495 | 189 | " |
| 46 | " " | 54,780 | 10,553,065 | 193 | " |
| 47 | " " | 52,775 | 10,588,170 | 201 | " |
| 48 | " " | 54,970 | 10,661,880 | 194 | " |
| 49 | Rainham Creek | 58,655 | 10,742,355 | 183 | " |
| 50 | " " | 59,385 | 10,821,875 | 182 | " |
| 51 | " " | 62,435 | 10,801,495 | 174 | M. |
| 52 | " " | 62,100 | 10,899,270 | 176 | T.C. |
| 53 | Wennington Sluice | 60,005 | 10,934,710 | 182 | " |
| 54 | " " | 62,925 | 11,006,930 | 175 | " |
| 55 | " " | 62,020 | 11,081,690 | 179 | " |
| 56 | Little Cold Harbour | 63,500 | 11,163,780 | 176 | " |
| 57 | " " | 66,730 | 11,256,610 | 169 | " |
| 58 | " " | 65,325 | 11,298,510 | 173 | M. |
| 59 | " " | 66,245 | 11,337,600 | 171 | T.C. |
| 60 | " " | 64,880 | 11,374,560 | 175 | " |
| 61 | Corinthian Yacht Club | 65,710 | 11,451,370 | 174 | S. |
| 62 | Upper Ballast Wharf | 72,115 | 11,565,800 | 160 | T.C. |
| 63 | " " | 68,945 | 11,639,420 | 168 | " |
| 64 | " " | 63,710 | 11,713,155 | 184 | " |
| 65 | " " | 64,660 | 11,751,800 | 182 | " |
| 66 | Erith Causeway | 63,570 | 11,791,605 | 186 | M. |
| 67 | " " | 66,425 | 11,859,505 | 179 | T.C. |
| 68 | Erith Pier | 72,020 | 11,968,790 | 164 | " |
| 69 | Easton and Anderson's Works | 71,245 | 12,085,670 | 170 | " |
| 70 | " " | 75,355 | 12,214,065 | 162 | " |
| 71 | " " | 72,105 | 12,310,390 | 171 | M. |
| 72 | " " | 75,065 | 12,329,475 | 164 | S. |
| 73 | " " | 66,390 | 12,506,975 | 177 | T.C. |
| 74 | " " | 70,110 | 12,604,995 | 180 | " |
| 75 | " " | 73,935 | 12,701,950 | 172 | " |
| 76 | " " | 70,735 | 12,783,990 | 181 | M. |
| 77 | " " | 71,460 | 12,817,435 | 179 | T.C |
| 78 | Crayford Ness | 68,365 | 12,885,730 | 189 | " |
| 79 | River Darenth | 71,660 | 13,255,415 | 185 | M. |
| 80 | " | 60,135 | 13,515,060 | 225 | S. |
| 81 | " | 64,250 | 13,660,245 | 213 | M. |
| 82 | " | 59,440 | 13,977,095 | 235 | L. & C. |
| 83 | " | 61,355 | 14,007,445 | 228 | " |
| 84 | " | 63,430 | 14,038,420 | 221 | " |
| 85 | " | 62,605 | 14,154,620 | 226 | M. |
| 86 | " | 63,620 | 14,163,440 | 223 | L. & C. |
| 87 | " | 65,100 | 14,188,970 | 218 | " |
| 88 | Little Powder Creek | 59,235 | 14,213,370 | 240 | " |
| 89 | " " | 60,555 | 14,238,670 | 236 | " |
| 90 | " " | 64,940 | 14,264,320 | 220 | " |
| 91 | " " | 63,000 | 14,294,355 | 227 | " |
| 92 | " " | 62,985 | 14,327,270 | 228 | " |
| 93 | " " | 61,155 | 14,359,865 | 235 | " |
| 94 | " " | 58,890 | 14,395,535 | 244 | " |
| 95 | " " | 72,400 | 14,540,545 | 201 | M. |
| 96 | " " | 64,530 | 14,796,625 | 229 | S. |

The foregoing table is calculated from sections plotted from soundings, those marked S. having been taken by Mr. Shelford in 1877, those marked M. by Mr. Mansergh in 1878, those marked M.B.W. by the Metropolitan Board of Works in 1879, those marked T.C. by the Thames Conservators in 1879, and those marked L. & C. by Messrs. Law & Chatterton in 1879.

Diagram 17 (*see Appendix* BG) shows the lines of the respective sections; the horizontal line A.A. is put at an altitude above the datum line, which represents a mean velocity of 196 feet per minute; and the line, looking something like a railway section of embankment and cutting, expresses at any particular line of the section the mean velocity of the water at half ebb at that section. Taking a mean velocity of 196 feet per minute, or about 2¼ miles per hour, as about that which would keep the river clean, we then see by the parts coloured pink where the velocity is too low, and by the parts coloured blue where the velocity is high; and if we examine this section we shall find that wherever a deposit has taken place we have the pink deficiency. At Woolwich, where a very large dredging has taken place, a very large deposit has formed; and the same at Galleon's Reach; the same at the southern outfall between Halfway Reach and Barking Reach, at Erith itself, which is shown by the long pink tint extending from Rainham Creek to the River Darenth. It will be observed that when the river passes into Long Reach the velocity rises very rapidly, and of course a deposit does not take place. Instead of taking an arbitrary line, I have taken a line which expresses the same velocity all the way, and enables us really to compare these things in a reasonable manner so as to get the result, and to see at once whether the current is too fast or whether it is too slow. We consider that a river, in order that it may maintain its depth of water or its area, must be what is termed in *régime;* that is to say, in train; that its velocity shall not vary beyond certain limits, and then the river will maintain itself. But if the velocities rise and fall to the extent that they do here, and if they are also assisted by the river being tortuous and of varying width, and so forming places which the tide does not reach, deposit is inevitable and is the natural result, and not the result of the accidental proximity of those places to the sewage outfalls which are quite inadequate to produce the result even of those shoals alone. That section which has now been placed before your Lordship (*handing in Diagram No.* 14, *see Appendix* BH. (1)) is a diagram of the low-water sectional areas of the River Thames between Jenningtree Point and Dartford Creek, being that portion of the river which is in question at Erith. The dotted line shows the sectional area of the river in 1833; the pink tint shows the increased sectional area which was given between 1833 and 1861. This will convey in a better way than anything else can the enormous extent to which the sectional area was increased; and I would submit that the sectional area has increased here exactly where these very mud banks are complained of. If we now compare 1861 with 1879 in the next section diagram No. 15, *see Appendix* BH. (2), we find that this increase has still gone on at the part below Erith where the increase before had not been so great; but the river having been made larger than it could carry, the sectional area has been diminished in the part between Jenningtree Point and Erith itself. The inevitable result of the river having been enlarged beyond what it could carry is that deposit takes place. Now if we pass to the next diagram No. 16, *see Appendix* BH (3), and compare it with the previous diagram, you will find that the places where the sectional area is diminished, as shown by the brown spots, are just the same as the spots where it had been made abnormally large. Now I am laying before your Lordship a plan No. 30, *see Appendix* BJ, which shows from actual experiment the course of the current. I may explain that these currents were taken by a float, but that the float was of a different character from that employed in the experiments made by the Conservators. The objection which we took to the float in those experiments was that, owing to its very great weight, it was not amenable to the small variations of the current; that a mass like that which weighed half a ton moving with a certain velocity, if it came into a current with a diminution or accession of flow, continued to move with its former velocity; because of its *vis inertiæ*, or its *vis viva*, its rate of motion could not be suddenly changed; that has been pointed out by Professor Unwin.

[*The witness produced his own float, and explained the same.*]

It floats in this way in the water: the white float is just visible above the surface of the water, it can be seen at a great distance in the day time; and in the night in order to avoid the necessity of making your boat fast to the float, which of course destroys the accuracy of all your experiments, we have a lamp upon it, and are thereby enabled to carry on our experiments continuously; and this float answers to every change of velocity. It was with that instrument that the observations I am now going to describe were made; plan No. 30, embraces the same portion of the river as that of the contour plans, namely, from Jenningtree point to Crayfordness, and there is a little table in the corner which gives the time of high and low water upon the several occasions when the currents were observed. Upon the 23rd November the float was put into the river at three o'clock, the low water that day being at half past six, so that this was the middle of the ebb tide when the tide was running down very strongly indeed upon the northern side, the float being put in half way between the Upper and Lower Ballast Wharves at Erith, and instead of going down the river it passed up the river with a velocity of 45 feet a minute in a reverse direction to the direction of the current flowing upon the opposite side of the river. It pursued its course until it reached a point when it had in fact travelled over a distance of half a mile, it then met the current coming down and ran out upon the course shown by the line attaining a mean velocity of 99 feet a minute until it got back to Erith pier. Another float was put in upon the same day at a quarter after three in the afternoon, and therefore about the same time as the first I mentioned. That was put in opposite the Upper Ballast Wharf, and its course is shown by the uniform dotted line. It passed up the river to a distance of a quarter of a mile with a velocity of 37 feet per minute, and then turned and ran down with a velocity of 118 feet a minute, until it had got opposite the Lower Ballast Wharf, when it was taken out. Another float was put in on the 24th November just before four o'clock, or 2½ hours before low water, opposite the Upper Ballast Wharf, that passed down for a distance of about three-eighths of a mile, when it met the return tide and passed with a velocity of 127 feet a minute until it was taken out by Erith Pier. These, of course, are definite and absolute experiments; and if the Commission visit Erith at any time they will see that while the tide is running down with great velocity upon the northern side, the yachts which are situated in this bight are lying with their heads in various directions, more affected by the wind than by the tide. In addition to those consecutive or continuous float observations, you will observe a number of arrows in the river; and when I say the whole of the observations we made were during the ebb tide, and that there are a very large number of arrows there pointing up stream, you will immediately see the state of the river in that part, which is simply this,—that having been made abnormally large at this part, the river, having acquired a certain velocity in passing down to this point, cannot stop itself suddenly,—it runs through itself and would leave a vacuum, unless water went past it in the opposite direction to fill the vacuum up; that is the way in which it happens. The water having obtained a velocity and not being able to change it immediately, rushes over the northern side and would leave a hole, only that water will find its level, and, therefore, the water runs back. And we have this proposition, which I know no engineer will deny, that if you have two sections of a river near together with the same quantity of water passing and the same sectional area, the mean velocity will be the same; but that if you have a sudden

*Mr. H. Law.*
30 May 1883.

enlargement and project the water with considerable velocity through it, a portion of the water must run back, and will give you a negative quantity, in which case the law will still hold that the mean velocities are the same. This is just an experimental expression of the mathematical law, and that is the cause, as we say, of the formation of the mud banks where this eddy takes place. We say that nothing you can do, short of embanking the river, will prevent the deposit of mud taking place and it is the fact. The Conservators produced a plan at the former inquiry, which doubtless, if the Commission wish to have it, will be laid before them; it was a plan which was prepared by the late Mr. James Walker, president of the Institution of Civil Engineers at the instance of the Corporation of London, who were the then Conservators, pointing out these very facts to the Corporation, that unless the Thames were trained, deposits and shoals would take place, and laying down by a red line upon the plan the line of embankments which were to be made to prevent it. But there is another thing which contributes to this, and for which the Conservators are in a measure to blame, and it is this, they do not limit the depth and extent to which people may dredge, so long as they do not dredge sufficiently near the wharf walls or piers, or other structures to endanger their foundations. But that is a great error, because if I make any portion of the river abnormally large, I am doing a great mischief, and I am really causing shoals to form in some other part; and that is a fact which has not been sufficiently realised by those who have now the government of the river.

13,931. (*Chairman.*) I perfectly appreciate your reasoning; but I should have thought that there would have been a strong downward current upon the concave side of the river at all times of the tide?—No, it is this. Your Lordship is quite right in supposing that under ordinary circumstances the current would hug the concave side, because a body in motion tries to move in a straight line. and would be continually constrained to change its direction, but you must look at the direction in which the water approaches. The water has been thrown across from Jenningtree Point direct upon Cold Harbour Point, and the straight line in which it is endeavouring to move is that straight line (*describing the same*); it has not been deflected from the north side to the southern side.

13,932. There has not been length of reach enough to deflect it?—No, it has rushed past Jenningtree Point in a line which is nearly horizontal on the plan, and it really strikes upon the northern side.

13,933. You have tested it by experiment, have you?—Yes.

(*Chairman.*) One remembers that when one used to row up the river, one used to keep upon the convex side when one was rowing against the tide.

(*Mr. L. Smith.*) Would your Lordship ask if there has been any corresponding experiment upon the flood tide.

(*Witness.*) I am coming to that now. This was only taken the other day, and we have not yet had it lithographed; we can only hand in one copy to the Commission and one to the other side (*handing in diagram No.* 36, *see Appendix* BK). Those are experiments showing the course of the flood, and your Lordship will see that in the same way the flood runs upon the northern side, and that the float, which was put into the middle of the river, just opposite the Erith pier, where these important banks are said to begin, only moved in the course of six minutes a distance of 300 feet, or at the rate of 50 feet in a minute. You will see the course taken by the several floats, the time at which they entered, and so on, and those floats ran with the full strength of the stream, but the float put in in the middle of the stream, you will see by the short line that indicates it, did not travel fast—that it was almost slack water in the middle—that in this bight the water was slack at both ebb and flood. If that bank were taken away to-morrow the deposit would go on again until it attained a certain limit.

(*Mr. L. Smith.*) Which is the short line?

(*The same was pointed out.*)

13,934. (*Mr. L. Smith.*) That is only six minutes?—Quite so.

13,935. (*Chairman.*) There is a bank of mud there?—It is a very large mud bank.

13,936. That must have been brought there by the water?—Undoubtedly.

13,937. It would not have been brought there by the water unless the water had gone there?—Undoubtedly.

13,938. Going up and down, it must have been brought there somehow and deposited, and had some sewage with it?—No doubt it had its due admixture of sewage—the whole of the water, we will say, contains a uniform mixture of water and mud—the water which is moving upon the northern side is moving with such rapidity that it carries that mud, whereas the water upon the southern side which contains the mud drops it.

13,939. Your argument is that it is not the sewage which has done it?—That is so.

13,940. My observation only goes to show that though the sewage has not done it, yet the sewage may have had its share in doing it?—We admit that immediately.

13,941. As adding to the solid matter in the river?—Yes, that is evident.

13,942. (*Mr. L. Smith.*) The banks which are formed are partly formed of sewage, are they not?—We do not quite admit that.

13,943. (*Chairman.*) You say that if the outlets were stopped, there would be a deposit of mud at that spot?—No practical change would take place.

13,944. But you will say that if the solid matter in the sewage adds to the matter deposited in the river, some part of it may have added to the bank?—Some part has been contributed by the outfalls, no doubt, but do not let us assume that that is sewage because sewage comes out of the outfalls.

13,945. But you say that it is made up of the solid matters of the water in the river, let that solid matter come from where it may?—Yes, sewage contains two parts; you may divide it into the part which is perishable and the part which is permanent, the permanent part may go to contribute to the banks, but the perishable part will not. Now, I have a word or two to say as to the character of the mud.

13,946. (*Sir John Coode.*) Your contention is that if there had been no sewage in the river, there would still have been a deposit of mud in the bed?—Yes; and as a matter of fact there was, because we show you what it was previously to 1865.

13,947. But now you say the solid parts of the sewage contribute in a greater or less degree to the deposit of the bank?—Yes, and I think now the Commission will appreciate why I went at some length into the comparative quantities of mud which came from the sewers and other sources, because, while I do not deny that in the ratio in which these two things exist, the outfalls do contribute to form the banks; I wish to impress upon you that the ratio of the sewage to other matters is so small that the effect of it is inappreciable.

(*Mr. L. Smith.*) Your Lordship will remember that in one of the earlier reports it was said that this position of the outfalls might be an unfortunate selection because of the slack water at that point.

(*Chairman.*) Have we had evidence as to the nature of the deposit upon the banks?

(*Mr. L. Smith.*) Yes, we had Professor Heaton and Mr. Lionel Beale, who had examined it chemically and microscopically.

(*Chairman.*) Have we had anybody who has stated of what it was composed?

(*Mr. L. Smith.*) Yes, there was some evidence with regard to that.

(*Witness.*) I do not think any of their witnesses went so far as to give the percentage of sewage in any

bank deposit; they seemed to think that that was difficult to do.

(*Sir John Coode to Mr. L. Smith.*) I think the evidence you gave was rather from non-chemical witnesses who spoke of the stinking character of it.

(*Witness.*) We shall have both chemical and microscopic evidence. I have only one observation to make with regard to the float experiments. I am not going through them. I only wish, so as to justify my not going into them, to read two questions. At Question No. 8212, Mr. Baldwin Latham was asked, "If that were so, if the float had been kept in the "displaced sewage, it would have gone down at the "rate of three quarters of a mile a day," to which he replied, "Yes, if the float could have obeyed the "natural flow of the stream, which it cannot, as the "velocity in every part of the stream varies, and one "float cannot give the mean of the stream; therefore, "you get these discordant results. (*Q.*) If the float "had been a part of the sewage, as we may assume, "it would have gone down the stream at the rate of "three quarters of a mile a day? (*A.*) Yes, the total "volume would, but I am pointing out that a particle "of sewage would obey the same action as the float. "(*Q.*) The action of the floats, therefore, conveys an "erroneous impression? (*A.*) They give the range "of the tides and not the progression out of the "river." Therefore, as that is admitted, I do not propose to say anything more at all about that, but I wish to call attention to what your Lordship put very clearly in this. You said, "Supposing the float "came out of the reservoir with the sewage, one "would suppose that it would go as fast as the "sewage, and, leaving the mixing action alone, one "would suppose that it ought to go down the river at "the rate of three quarters of a mile a day. I do "not say that the sewage may not find its way up "the river, because a quantity of sewage may get "a certain distance up, and then it may stop in an "eddy, and it may be again carried up by the next "up-tide, and taken still further; but it seems to me "that what Mr. Bidder is contending for is demon-"strated," and the witness said, "I say the floats "only show the horizontal oscillation, and have "nothing whatever to do with the ordinary displace-"ment." Then Sir Peter Benson Maxwell said, "Mr. Bidder made a statement to the effect that the "sewage did go at a certain slow rate. Now either "your tables go to contradict that statement, or they "do not. If you admit that they do not then surely "the cross-examination may be very materially "shortened. Do they contradict it?" and the witness answered, "What we say is that the floats only show "the oscillation, and have nothing whatever to do "with the progress. We have already shown the "progress. We admit Mr. Bidder's argument with "regard to the oscillation, and we have given "evidence as to the mixing question, showing that "the sewage does get out of the river under "varied circumstances. (*Q.*) Then these floats do "not contradict Mr. Bidder? (*A.*) They do not. "(*Mr. Bidder.*) But nevertheless these floats are "large bodies 12 feet high, and not obeying the "flow of the water, whereas the sewage is in minute "particles in suspension and obeying every motion of "the water."

13,948. (*Chairman.*) What are you doing—are you giving us evidence, or are you reasoning upon the evidence of your opponents?—I am going to found an observation upon this—then Mr. Baldwin Latham replied, "I admit that; but still there is evidence to "show that wherever these floats have gone sea water "has gone, and wherever sea water has gone sewage "has gone, because the sea water could not have "been carried up the river past the outfalls without "carrying sewage with it;" that is the point I wanted to bring out—that, practically, the float experiments have been thrown over upon the other side with this exception, that they said that, having been put in with the sewage at the outfalls, they did arrive ultimately at Chiswick or at Putney or at Hammersmith, and then they say that wherever they went sewage might have gone too. It is important to consider whether that is so, so I have just taken out what happened to these particular floats which did go to Chiswick and I have only one word more to say about them. No. 3 float, for instance, started at low water when the sewage water would have been considerably further down the river, and after 12 days, and having travelled 538 miles, it has arrived at Chiswick; but it is hard to contend that a piece of sewage could have existed 12 days in the river, and travelled 538 miles, and still have been sewage.

13,949. How did it get up there?—By the continued oscillation.

13,950. That is what happened?—One of their floats found its way up to Chiswick, and they raise upon that the argument that, inasmuch as that represents what might have happened to the sewage, sewage might have gone there; but I am representing that the float had spent 12 days in doing that, and that it had travelled 538 miles, whereas the most persistent sewage could not do that.

13,951. Then it would have been oxidized by that time, you mean?—Yes. No. 5 float in the same way occupied 6 days, and travelled 356 miles, going to Putney Bridge.

13,952. You do not deny the possibility of the float having *bonâ fide* run up to Chiswick, do you?—I do deny the *bonâ fides* of that particular float No. 3, because I know what happened to it; but I do not wish to carry that any further.

13,953. Where was it put in?—At low-water at Barking; and I think we have some evidence of what did happen to it upon a particular day, but after what has been said upon the other side by Mr. Baldwin Latham, it would be labouring the case, and taking up your Lordship's time unnecessarily, to go any further into them.

13,954. (*Mr. L. Smith.*) When you say you have some evidence, do you mean some evidence you are going to call; is that what you mean?—No; I think it has already been before the Commission.

13,955. Then I should like you to point out some evidence which goes to show that float No. 3 was tampered with?—It was put to one of your witnesses in cross-examination.

13,956. But when you say there is some evidence as to No. 3 float, are you pointing to something that is upon the notes on something that you are going to prove?—I think it was put in cross-examination to one of your witnesses.

13,957. But I want to know, when you say you have evidence as to this particular experiment, do you mean to say that the float has been tampered with?

13,958. (*Chairman.*) I think it was an unfortunate expression of mine that led to this discussion. (*To the witness,*) You did not mean to say that it had been tampered with?—No, not in that sense.

13,959. I used the expression "a bonâ fide experiment"?—I had in my mind the fact that we had pointed to that float in cross examination. Now a good deal was said as to the comparative state of the river with the state of the river many years ago, when the water was said to be fit for drinking and making tea, and so on. Now in making the Thames Tunnel we were very much and seriously inconvenienced by the character of the ground which came down from the bed of the river into the excavation, and I have a letter of Sir Isambard Brunel, addressed to Mr. Browell, who was the analytical chemist to Guy's Hospital, another to Mr. Brand; and Dr. Faraday was consulted, and I have one or two notes of what happened upon two or three days when we had poisonous gases, and inflammable gases which came into the shield caught fire and burnt for a considerable time, and the health of our men was affected to a very considerable extent by those emanations. I propose on this point to read a note of my own made in 1839.

13,960. What do you say that shows?—It shows that the mud which came from the bed of the river at that time, was of such a character that it gave off large

*Mr. H. Law.*

30 May 1883.

quantities of sulphuretted hydrogen and other gases, one note of mine would show it to your Lordship. On the 30th April 1839, "A considerable rush of ground "took place, bringing with it every description of "river deposit and dirt, a root resembling a sea-weed "in a fresh state, oyster shells, &c., accompanied by "a very strong effluvia. The stench in clearing out "the frames was horrid, the ground thus removed was "black mud, river deposits, small coals, and masses "of black clay, with sand smelling strong of gas "refuse," that was our experience of the nature of the bed of the river at Rotherhithe at that time.

13,961. That was before the sewage was turned into the river?—Yes, that was before the sewage was turned into the river, because at that time almost all the houses were drained into cesspools, and it was an offence at common law to carry the overflow from a cesspool into a sewer, and it was not until Bramah invented the water-closet that the connexions were made surreptitously, and at last they were made so extensively that the law was altered, and from being prohibitive it was made compulsory.

13,962. I thought Mr. Edwin Chadwick was the inventor of the scheme of sewage?—No, the great fight with Mr. Chadwick was about small pipes as against large sewers. Then I will refer the Commission to the first Report of the Thames Conservators after their constitution. In the first Report, which was issued upon the 31st December 1858, the Commissioners will find a lengthy description of the state in which the river was then. I merely wish to call your attention to that. I would also call the attention of the Commissioners to a joint report which was made by Sir Joseph Bazalgette and myself and my partner upon the 15th of April 1878, in the Appendix to that Report which I think has been put before the Commission; you will find a reference to the state of the river in 1858, the letter of Mr. Faraday and a copy of the statements laid before the Lord Mayor as to nuisances arising from the docks and other matters of importance. Now upon the 7th of November 1872 (I should mention that I acted as shower upon the previous arbitration inquiry) upon that occasion I went down the river with Sir Charles Hartley, Sir F. Bramwell, Captain Galton, Mr. Pope, Mr. Bidder, Mr. Clark, and Mr. Aston; I represented the Metropolitan Board of Works, and Captain Burstal and Mr. More, represented the Conservators. We went down in the Conservator's steamer, and the Conservators had their appliances for dredging up the mud and for collecting it; they dredged up the mud wherever they pleased, and they also collected it upon the shore, and the mud so found was perfectly inoffensive. We went exactly opposite to Crossness, in the middle of the bank which is alleged to consist entirely of sewage. The mud was brought up through an instrument formed on purpose, and as I say the mud so brought up was perfectly inoffensive. We then ran down the river and took it from the banks in every direction, and after that I, as shower, challenged Captain Burstal to produce a mud of an offensive character, and he could not; and if the Commission make themselves the same investigation it will be the most conclusive proof I should think to their minds of the real state and character of the mud. No difference was able to be detected in the mud in any part of the river. I have now only one remark to make, and that is in regard to the pollution of the wells. At question 7944, Mr. Baldwin Latham suggested that this inquiry was really of great importance as affecting health, because it was possible that the wells which supplied water for drinking purposes might be polluted; he was asked, "Now passing from "that to another matter, in your judgment is the "discharge of the sewage into the River Thames in "any way likely to affect the wells in the neighbourhood," and he said, "Yes, it is." I only wish to point out that in the sections which I deposited yesterday with the Commission I showed that the water which exists in the chalk stands at a very high level of 400 feet at a distance of some miles from the river and falls with a gradual gradient towards the river, and from that I would put before you the fact that the water will run from the wells into the river and not from the river into the wells.

13,963. I was thinking of that. I was expecting you would say it, but are there no wells where the water stands at a lower level than the high-water of the Thames?—If there were that would prove incontestably that some impervious stratum of clay existed between that well and the river, and therefore, must cut off access to it, otherwise the water from the river would reach its level in that well.

13,964. That is very ingenious and rather points to this dilemma, that is to say, either the water is always higher than the level of the Thames, or else there in an impervious wall there between them, but you know the spring may be a short supply, and the consumption may be considerable, and the water might be kept down in that way?—But the cases which have been put are rather these; the proof of the influence which the tide has upon the well has been founded upon the fact that the water rises and falls in the well in sympathy with the tide, and that may very well be.

13,965. Is there any evidence to that effect?—Yes, that has not been denied, but if you consider that the water is always flowing through the chalk, if I stop that by the increased pressure of the tide, I make an artificial hydraulic ram with very slow beats and at very long intervals. I think that that concludes all I have to say.

13,966. Before you are cross-examined I should like to ask you one question. Suppose you could take the sewage 20 miles further down upon each side for nothing, would you do it?—No.

13,967. You would not?—No, not 20 miles, because you would then take it from a place where we say it does little or no mischief to a place where it would do a great deal of mischief.

13,968. Where do you mean?—At Gravesend.

13,969. But considerably below Gravesend, I would say?—Yes.

13,969*a*. Supposing it could be done for nothing, would it be a good thing to do?—Yes, if I could do it for nothing I should not hesitate to carry it down into the open sea. I have always advocated throwing it into the sea if you can.

13,970. Then it is some nuisance where it is, apparently?—No, I cannot say that it is a nuisance.

13,971. Then why would you like to take it further away?—Because I should like to see the river as pure as possible. It is necessary in the first place to define what is meant by a "nuisance."

13,972. And that is very difficult to define?—I will put it in this way. I believe that no person passing up and down the river, if they were not told that the sewage was discharged into it, would ever find it out. I will put it as high as that.

13,973. (*Sir John Coode.*) Not at any time or under any conditions?—Not unless they were to row within, perhaps, a distance of 100 yards of the outfall itself, and then their attention might be attracted to it. And I will also call your attention to this fact, that while I say the sewage is not practically appreciable there do exist and higher up the river, for instance at the entrance of Bow Creek, Messrs. Odam's works, works which I have seen within the last six months upon a fine frosty morning, with the sun shining, throwing out clouds of steam and smoke, which obscured half the river, and the stench of which was intolerable. The stench from the salicylic acid is intolerable, and I would also say that from the barges which pass down the river containing putrid bones you would see a column of visible steam rising into the atmosphere from the hold, and if you are within 150 yards, in a leeward direction, the stench is so nauseous that it is impossible to conceive anything more offensive. The men on board, I understand, do not suffer so much, because it is so hot from the putrefaction that the stench rises up directly and passes a little way off. Many of these things occur

in large rivers like the Thames, and these are nuisances, but I really consider the nuisance of the sewage is inappreciable.

13,974. (*Chairman.*) Was it in contemplation by the Metropolitan Board of Works to make another main sewer in the north with the view to preventing some of the storm overflows which now take place, only that they hold their hands till they know what will be the result of this Commission ?—No; what has happened is this, that in certain districts, and in the low parts of those districts, the sewers have been filled to an extent that, instead of receiving any more rainfall, it used to pass out into the neighbourhood. At Kennington, for instance, the great Effra sewer, which was a recognised natural brook, in very heavy rains proved insufficient to take the water, and the Board built a new sewer to carry away the storm water, and those works are being carried out and will soon be completed. But the works as to which they hold their hands till the completion of the report of this Commission are as to the enlargement of the reservoirs at Barking and Crossness so as to avoid the necessity of letting the sewage pass out during the flood or continuing so long during the ebb.

(*Chairman to Mr. Lumley Smith.*) Do not suppose that we are going to find any fault with the evidence which you have given with the view to showing that the sewers are not adequate to carry off as much rainfall as they ought to do, and that consequently there is an overflow of sewage occasionally in the upper part of the river, and indeed occasionally all the way from Hammersmith downwards; we do not complain of that; but is there any evidence that that is productive of any sensible or appreciable nuisance to anybody ?

(*Mr. Lumley Smith.*) No, but it is the foundation of an argument that the contention on the part of some of the witnesses that it is pure water which comes down to dilute the sewage at Crossness and Barking is erroneous, because it comes down already polluted with what has flowed out from the storm outflows in London, and that is the way in which we have thought it important.

(*Chairman.*) Of course when it comes down from the storm overflow it is not as good as it would be if there had not been any outfall from them; but at the same time, it comes down in increased volume evidently.

(*Witness.*) May I make one remark on that, which is this, that whether it is diluted by an enormous quantity of rain before it gets to Barking, or when it gets to Barking, is of very little consequence.

13,975. (*Chairman.*) That is the remark I was going to make; that is to say, your sewers at Crossness are discharging a less sewage mixture than they would have been doing if there had been no rainfall ?—Quite so, because the sewage of the people themselves is not affected by the rainfall; that is not increased.

13,976. (*Chairman to Mr. Lumley Smith.*) If you think it is an important matter to continue, the Commission are not going to make an interlocutory award against you in any way, but it certainly strikes us that it is not the great question that we have before us; and to say the truth, without compromising any of my brother Commissioners, it strikes me that although it would be a good thing if it were possible never to have storm overflows at all, yet the expense to which the public would be put to obviate them would be so enormous, and the amount of injury you have shown resulting from it is, if anything, so little, that it would be very difficult to say much about it.

(*To the Witness.*) I think Sir Joseph Bazalgette said it would cost 8,000,000 of money to have separate sewers, and certain expense to each house ? —In many cases it would be impossible; in any case it would mean the duplication of the system of sewers. It would cost, without making even a rough guess, an enormous sum of money.

(*Mr. Lumley Smith.*) We have rather obeyed the instructions of the Commission in not bringing any evidence as to any remedy for the evil, or how it would be done, or what it would cost; our evidence has been, no doubt, that the condition of the Thames at London has been improved enormously since this system came out, but what has been said upon the part of my learned friend is that so much pure water comes past the outfalls that it must prevent the sewage being a nuisance locally.

(*Chairman.*) I will say no more than I have done, but perhaps both sides will think of it, and they will really see that the grand question is the condition of the river between Greenwich and Purfleet.

(*Mr. Lumley Smith.*) Certainly. Now, there is such a great quantity of matter involved in Mr. Law's evidence that if my learned friend could take another witness next Tuesday, and let us take Mr. Law the week after, because the evidence cannot be given us till next Tuesday, it would be very much more convenient to us.

(*Mr. Norman Bazalgette.*) I am told that it will put the Board to extreme inconvenience, as the engineers and the various witnesses evidence is so dovetailed, to interpolate another witness.

(*Chairman.*) I cannot help thinking that that is rather a fanciful objection.

After some discussion, it was agreed that the cross-examination of this witness should be postponed till Tuesday the 12th of June.

Adjourned to Tuesday next at half-past 12 o'clock.

# THIRTY-SEVENTH DAY.

## Tuesday, 5th June 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
FRANÇOIS DE CHAUMONT, ESQ., M.D., F.R.S.
THOMAS STEVENSON, ESQ., M.D.

WILLIAM POLE, ESQ., F.R.S., *Secretary.*

Dr. JOHN WILLIAM TRIPE called in; examined by Mr. NORMAN BAZALGETTE.



13,977. You are a Doctor of Medicine, a member of the Royal College of Physicians of Edinburgh, President of the Society of Medical Officers of Health, and Medical Officer of Health for the Hackney District ?—I am. I have been 26 years Medical Officer of Health.

13,978. I believe for some time past you have been pursuing an investigation with a view to determine

*Dr. J. W. Tripe.*

5 June 1883.

14,001. Of course it is always possible that the people at Woolwich are being poisoned by the sewage, and that the proper quantity, instead of being 11 ought to be 1, or 2, or 3, and that the people at Greenwich are not indeed poisoned by the sewage, but by something else, is there any possibility of that?—In Greenwich there has been always a little excess of diarrhœa, there is something peculiar in the way in which diarrhœa lays hold of certain districts without a person being able to tell why. Whether it is in the soil or not I cannot say, the water in Greenwich is the same as in the other places; and yet there is the fact that Greenwich has suffered more from diarrhœa since 1866, though not to any great extent, except in the case of this particular epidemic which has been most severe, so that that 18·18 would be reduced to about 14, if you take away the excess for those four years of diarrhœa and measles, and reduced it to the average, but I have given you the facts as they stand.

14,002. (*Dr. Stevenson.*) Do you think that the density of population has anything to do with the difference in number?—Yes, but it is odd enough that the parts which are most dense in population appear to be those which have suffered least. And, perhaps, having got so far as that, I might be allowed to reply to that question as to what I thought was the cause of these results. I think that the air from the river blows out the bad air from the houses which are near, and that there is nothing injurious carried from the river to the houses, and that consequently the people are healthier in the vicinity of the river than they are away from it.

14,003. (*Chairman.*) But it is obviously consistent with that reasoning that the people might be healthier still if there were no sewage there?—That I cannot say anything about, excepting that it will be seen that the diseases which are considered to be those most likely to be caused by emanations from the river are not found in the vicinity of the river, that is the point.

14,004. That is a just remark, certainly?—If you look at the figures, it is the fact.

14,005. (*Sir John Coode.*) Can you tell us what is the proportion of dwellings along the immediate river bank to warehouses, taking Woolwich for instance?—At Woolwich I think you will find there very few warehouses.

14,006. I would like to know what is the fact with regard to the proportionate number of dwellings to warehouses immediately along the river bank compared to the area further in?—If you look at the map you will see there are a number of small streets running down to the river, and yet there has not been a single death from zymotic disease in these four years. Then if you go further on to Warren Lane, which runs down to the river, and Harden's Lane, which comes down to the gasworks, the same remark applies, as it is nearly a quarter of a mile which I take as the limit. I thought that would be a fair distance to take from the river bank.

14,007. My question referred to the belt immediately along the river bank?—I admit there is a difficulty especially in regard to Greenwich; but Rotherhithe, which I shall come to directly, will show you a fact which is very striking indeed, because there you get a line of houses right along the river. It is true it is chiefly on one side, but it runs along the whole river front, and yet in Rotherhithe Street there is only along the whole of the three quarters of a mile only one death from diphtheria.

14,008. But one sees, coal wharf, coal wharf, and so on, on the plan?—Yes, but if you refer to Erith you will see that Erith does not come down, as a rule, close to the river, even allowing for the wharves.

14,009. (*Mr. Beaumont Morice.*) And, therefore, there are few deaths?—There are wharves there, but they are at no great distance, and you have houses even on both sides in some parts.

14,010. (*Sir John Coode.*) I suppose in many cases there is a caretaker who lives upon the wharf?—I daresay, but with regard to this particular case of diphtheria in Rotherhithe Street was registered as "diphtheria peritonitis." Now it seems to me that this could not have been a death from diphtheria at all, but I put it down as diphtheria because it was entered in the return as diphtheria; but I think there are several of those deaths which ought not to have been registered as being from the diseases entered in the certificate. I think the medical gentlemen upon the Commission will admit that a death from "diphtheria peritonitis" could scarcely be considered to be a death from diphtheria.

14,011. (*Mr. Norman Bazalgette.*) If that one is eliminated, the only death from diphtheria in the neighbourhood of the river disappears?—It does.

14,012. (*Colonel Ewart.*) In your investigations at the hospitals, or otherwise, have you obtained any statistics as to cases of those diseases, because your statistics are entirely limited to deaths, are they not?—I only took out the deaths from the hospitals.

14,013. You have no statistics as to the recoveries?—I have not.

14,014. (*Sir John Coode.*) Do you think that that is a true gauge, that the ratio of deaths will give us a true idea of the ratio of disease?—I think the result of the figures of the hospitals shows that ordinarily the proportion of attacks to deaths, as a rule even, differs very little. Scarlet fever is an exception, probably, and small-pox also occasionally, because attack of hæmorrhagic small-pox cause a larger proportion of deaths than ordinary confluent small-pox. In the same way there is a kind of scarlet fever which kills before the rash comes out.

14,015. I only wanted to know the general conclusions to be drawn; is the death rate a fair criterion of the ratio of disease?—I think fairly so, because it is found from the experience of hospitals, as a rule, that there is a proportionate rate between the death and the disease.

14,016. (*Dr. Stevenson.*) Do you know any better mode of arriving at a true result?—No, I do not. You have here reliable data; whereas if you take anything else you would get into an unending mass of confusion; you would have to go to the medical men, both in and out of the district, and you would have very doubtful evidence to rely upon. I know of no evidence better than this.

14,017. (*Sir John Coode.*) Or so good?—Or so good. I shall have to point out to you my reasons for adopting a somewhat theoretical basis of calculation, namely, calculating the number of zymotic diseases to the deaths from all causes; but I will refer to that by and bye.

14018. (*Mr. Norman Bazalgette.*) Will you call attention to the Greenwich spot map now?—Yes. This area is more limited than it would have been if I had decided upon the spot map system at first. I may say that these statistics were not got out with the idea of making a spot map, and therefore perhaps you may say that the results are either more or less satisfactory, according as you may regard them, otherwise I should have extended the district in Greenwich, which is rather limited. I thought we should be able to get at the census, but there were certain difficulties at Somerset House with regard to the census, so that the only census that I have is that of the training ships; therefore it is that I adopted the percentage of zymotic disease to total deaths. Now you will see by the Greenwich map that there are wharves and quays at Greenwich. The difficulty with Greenwich is that nearly the whole of the river frontage is occupied more or less by wharves. I visited three streets at Greenwich. I thought this was the plan that would give the fairest results. But here again, in the same way as in the other case, in fact to a greater extent; the deaths at Greenwich occurred away from the river, far more than anywhere else; and it is very striking indeed, that in these four years you have but one single death from scarlet fever near the river, and that is in Bennett Street. There is one in Newcastle Street, half a quarter of a mile from the river; but in the other cases you will see there is a much larger proportion of the deaths in Chester Street, about the

middle of the area than elsewhere. It bears out precisely the same thing, but, as I say, those deaths were not got out with the idea of making a spot map. I was not satisfied with Table 1, and therefore thought I would see what evidence a spot map would give me. Now I will refer to Rotherhithe; I went to three different areas in Rotherhithe before I chose this one. I have also mentioned the long Rotherhithe Street, and pointed out one diphtheria case which I consider doubtful. You will see in that block of houses betweeen Paradise Street and Rotherhithe Street, where you get an exception to the rule, the river frontage is quite blank, it is a very poor neigbourhood, and very much crowded. You will see there has been a large number of deaths from scarlet fever in that bit of the district, and also one from diphtheria, but no death from diarrhœa or typhoid.

14,019. (*Sir John Coode.*) Princes Street also appears to be a very bad locality?—In Princes Street, which runs at right angles with the river, there were two deaths from diphtheria, one from diarrhœa, two from scarlet fever, and two from typhoid fever, it is the only instance of that kind of thing occurring; and there you see that the spots are partly distributed away from the river, and partly near to it.

14,020. (*Chairman.*) There are one case upon one side, and seven on the other?—Yes. Then in Adam Street, Albion Street, and Risdon Street, you will see that there is almost a similar kind of aggregation of disease, whereas, as I show, all along the bank, along Rotherhithe Street, there is nothing of the kind. Elephant Lane is a very poor street, but Princes Street is not so poor as Elephant Lane, where you get three deaths from diarrhœa.

14,021. (*Sir John Coode.*) Did it occur to you to make any inquiry as to what were the sewerage rarangements of the street where you had the largest number of deaths?—It did not.

14,022. It did not occur to you?—I cannot say that it did not occur to me, but the place is so spotted round about that I did not make an inquiry.

14,023. (*Colonel Ewart.*) Are they an old class of house?—They are; but Princes Street is wider than Elephant Lane in fact. I cannot account for the outbreak. I may now say that before considering the poverty of the people, and the condition of the place generally, and the number of people apparently living in the houses with their children, I came to the conclusion that the only way in which I could account for it was that the air from the river blew away the bad air which might form a *nidus* for the spread of disease. I use the term "*nidus*" advisedly, because I know no other which would give the precise impression I want to convey.

14,024. At any rate, as far as the facts go, they show that the districts upon the margin of the river enjoy a certain immunity from deaths from zymotic disease?—They do.

14,025. Can you tell me whether the number of deaths per thousand from zymotic disease varies according to the density of the population, as well as from other causes?—I got out from the supplement to the 35th Report of the Registrar-General, which is a mine of wealth to the statistician, the following table which is somewhat singular, and this is one reason why I decided to compare the deaths from zymotic disease to the deaths from all causes. The deaths from all causes and from zymotic disease of persons of all ages during the ten years 1861–70; taking the healthy districts as 100, were in all England 138, and in Liverpool 229. Of those of all ages from the seven chief zymotic diseases, the healthy places being taken at 100, there were 140 deaths in England, as against 138 from all causes, and at Liverpool 232 against the 229 deaths from all causes, so that the relation of the deaths from zymotic disease, to deaths from all causes in these ten years, is so singularly close that I think it may be taken as a reasonably fair and accurate basis for calculating the death rate. I must say that, as a statistician I was rather astonished, and very pleased to find that I was right in adopting that basis. I undertook this calculation expecting that the result might be totally contrary. The results are best shown in a tabular form as follows:—

*Dr. J. W. Tripe.*

5 June 1883.

The Number of Deaths in England and Liverpool from all Causes and from Zymotic Diseases to 100 Deaths in the healthy districts, 1861–1870—

| | Healthy Districts. | England. | Liverpool. |
|---|---|---|---|
| Deaths at all ages, and from all causes - - | 100 | 138 | 229 |
| Deaths at all ages from seven chief zymotic diseases | 100 | 140 | 232 |

14,026. (*Mr. Norman Bazalgette.*) Applying that to the selected districts, what do you say for the four years from 1878 to 1881?—The zymotic death rate in all London was 16·23 per 100 deaths from all causes; whilst in the riverine areas selected it was 12·85 in Greenhithe; 13·26 in Erith; 11·14 in Woolwich; 18·88 in Greenwich, and 23·67 in Rotherhithe. Now in Greenwich, as I have already pointed out, that excess arose from measles and from diarrhœa. The death rate from measles was 7·29 and 7·72 from diarrhœa, which, if you look at Table No. 1, you will see are enormously high as compared with the death rates from the same diseases in other districts. If the excessive death rate from measles be reduced to an average, the total death rate from these diseases would be only 13·88; but as the high death rate from measles was accompanied by a diminished death rate from scarlet fever, it would be fair to assume that the zymotic death rate in the Greenwich area would be about 14·5, or it might be as high as 15 per cent. of the total deaths, allowing for the deaths which would have taken place from other diseases if the deaths had not taken place from this one.

14,027. (*Sir John Coode.*) There is a very high death-rate from diarrhœa as well as from measles?—Yes; and I say, if you take the two into consideration the death rate will be reduced to 13·88, and if you take the average it would be 15.

14,028. (*Mr. Norman Bazalgette.*) That is as compared with 16·23 for the London death-rate?—Yes.

14,029. (*Chairman.*) There is a singular coincidence as regards the large quantity of deaths from measles and from diarrhœa at Greenwich. Does tha suggest the idea that similar causes may have produced them?—No; because diarrhœa has not prevailed to anything like that extent, except for those four years. Why it should have prevailed during those four years I cannot tell; the water supply may have been fouled during those four years for anything I can tell.

14,030. (*Dr. De Chaumont.*) You do not suggest that measles or whooping cough are connected with sewage?—No; and therefore I strike them out of my spot-map. I do not consider they are in any way connected with it.

14,031. (*Mr. Norman Bazalgette.*) I believe that the figures from deaths from zymotic disease are higher in Rotherhithe than in any other parts of London,—can you account for that in any way?—I account for it chiefly by the character of the population and the number of children, as from the Registrar-General's supplement to the 35th Report, I would mention this fact. The deaths of children under five years of age from all causes and from zymotic disease in England and in Liverpool, compared to 100 in the healthy districts from 1861 to 1870, was in England 150 from all causes and 155 from zymotics; but in Liverpool, where there is a very large number of young children, it was 262 from all causes and 343 from zymotics; of course you will remember there, the extreme density of the population and the large number of poor.

14,032. (*Sir John Coode.*) Liverpool has about the highest death-rate in the kingdom for a large town?—Yes; but the deaths under five years of age from all

*Dr. J. W. Tripe.*

5 June 1883.

causes were 262, while the deaths from zymotic diseases at the same ages were 343.

14,033. As compared with 155 for the rest of England?—Yes; so that it is evident that if you compare the two tables together as to the comparison between England and the healthy districts at all ages, and then compare those under five years, you see an enormous increase of the death-rate in Liverpool from zymotic diseases; and therefore it is that I consider the same thing has occurred in Rotherhithe,—it absolutely swarms with children, and especially the part near the river. I think I scarcely ever saw a district which was so swarming with children, and many of them without shoes and stockings. Now these children would be of the same class as those at Liverpool, and therefore one might have expected a high death-rate from that circumstance. That is borne out by the facts, inasmuch as the proportion of deaths amongst young children in Liverpool under five years of age is larger in proportion than in any other district, bearing out this fact which I have mentioned, and which I think fully accounts for it.

14,034. Does not that large death-rate in Liverpool apply to those above five years of age as well as to those below?—Yes; in all England the number of deaths under five years, from zymotics was 155 whilst in Liverpool it was 343, or more than double; and from all causes the number of deaths under five years in England was 150, whilst in Liverpool it was 262.

14,035. (*Mr. Norman Bazalgette.*) Did you hear Dr. Corfield give his evidence?—I did.

14,036. Did you hear him say that that he did not consider the high death-rate from zymotic diseases in Saint Olave's, Southwark, of which I believe Rotherhithe forms a part, was caused by the state of the river?—I heard him say that in cross-examination, and I quite agree with him.

14,037. The evidence of the spot-map corroborates that, I believe?—I believe it does fairly; I cannot say that it does to the same extent in other districts.

(*Chairman.*) What was the general effect of Dr. Corfield's evidence?

(*Mr. Norman Bazalgette.*) I think the general effect of Dr. Corfield's evidence was to show that statistics prove the opposite of what Dr. Tripe says they do.

(*Chairman.*) Did Dr. Corfield go into the figures?

(*Witness.*) I am going to criticise Dr. Corfield's evidence if you will allow me to do so. I would say, with regard to Dr. Corfield's tables, in the first place, that I look upon them as not reliable for comparison to a certain extent,—first because the deaths, which were very numerous, in the Asylums Board Hospitals from fever and scarlet fever, and small-pox,—the deaths in the Small-pox Hospital at Islington, the Fever Hospital at Islington, and the various infirmaries which are outside the metropolis,—were not distributed to the parishes from which the cases were brought. I quite admit that it would be almost impossible to have got that out for the whole of London, but it can be got to a certain extent which I shall submit to you to show to a certain extent how far these errors have crept in. There is also another thing which I think is very strong indeed in regard to cases of fever. Dr. Corfield returns all cases of fever as fever. Now simple continued fever and fevers of uncertain kind and origin, typhoid fever and typhus fever, all of which are grouped together into one figure arise from different causes, so that Dr. Corfield himself, if he had been asked, would never have said that typhus fever was caused by the same thing as typhoid fever, or simple continued fever. Typhus is simply a disease of poverty and overcrowding.

14,038. (*Chairman.*) Is it infectious?—It is highly infectious. When I say "poverty and overcrowding," I mean the necessary concomitants or attendants on poverty or overcrowding.

14,039. General insanitary conditions?—Yes, that is so. I may say here that I do not believe that the river or the drains by themselves, irrespective of germs, ever caused typhoid fever, small-pox, scarlet fever, or whooping cough; but I believe that insanitary conditions render persons more susceptible to taking the disease, and also that by producing greater debility and a bad state of the blood, owing to the blood not being properly aerated, those diseases are apt to prove more intense than they otherwise would have been. I would also point out that Dr. Corfield said that he looked upon scarlet fever as being more likely to be influenced by the river. Now, if you look at the spot-map, you will see there is very little scarlet fever near the river, except in Rotherhithe.

14,040. Did Dr. Corfield give us statistices in the same way as you have done?—Yes. Table 2 is a comparison between my statistics and Dr. Corfield's, as far as I have been able to give them. I could not go back earlier than the year 1856, because the diseases were not then published in a separate form; but I could take the years 1856 to 1865, as against 1871 to 1880. There is however a difficulty here, namely, that zymotic diseases were more prevalent in all London during the years 1856 to 1865 than in 1871 to 1880. As that prevalence ran through the whole of that period, the death-rate from the chief zymotic diseases in the years 1856 to 1865 was 4·64 for all London; against 3·83 in 1871–80 being a difference of 17·5 per cent. Now it would have been unfair towards Dr. Corfield's Tables if I had compared 1856–65 with 1871–80 without making a deduction for that increase; so I have corrected them by deducting the 17·5 upon the zymotic death-rate, for 1856–65 in order to make it compare with the death-rate for the whole of London during 1871–80. If you turn to Table 5, you will see that it includes those parts of the district of St. Olave's, which were near the water,—the riverine districts,—which were given by Dr. Corfield; and also the two sub-districts, Leather Market and St. Mary, which were not near the river, and therefore entirely out of the influence of the river. Now the zymotic death-rate is 4·46 for the district near the river, that is to say, after I have allowed for deaths in hospitals, which I have corrected as far as I could.

*Table No 5 was handed in and was as follows:*

TABLE No. 5.

Compiled by JOHN WILLIAM TRIPE, M.D.

*Zymotic Deaths.—Annual Average Results for the 10 years 1871–80.*

PROPORTIONS TO 1,000 PERSONS LIVING.

| Sub-Districts. | Small-pox. | Measles. | Scarlet Fever. | Diphtheria. | Whooping Cough. | Fever. | Diarrhœa. | Cholera. | Total Zymotic Death Rate. |
|---|---|---|---|---|---|---|---|---|---|
| St. Olave's, Southwark<br>St. John, Horsleydown<br>St. James, Bermondsey<br>Rotherhithe | 0·26 | 0·59 | 0·81 | 0·18 | 1·08 | 0·40 | 1·07 | 0·07 | 4·46 |
| Leather Market<br>St. Mary | 0·51 | 0·83 | 0·68 | 0·07 | 1·15 | 0·34 | 1·42 | 0·02 | 5·02 |

14,041. (*Chairman.*) What are we doing in St. Olave's, Southwark?—That is Dr. Corfield's table.

14,042. Suppose we do not bother about Dr. Corfield?—If you are content I will not bother about it any more, I mentioned it because it led to this,—that in the sub-districts away from the river the mortality was high, the zymotic death-rate being 5·02 as against 4·46 close to the river. I leave that to the Commission what it is worth. You will see in Table 2 that I criticise Dr. Corfield's Tables and the results I have arrived at are those which I have mentioned before.

If you follow out Table 2, you will find that as the sewage is moved away from a district, the deaths from zymotic diseases become more, and when it is taken down to other districts it becomes less in those districts; but of course I do not by any means mean to say that the sewage being poured into the river has that effect, but there is the fact.

14,043. You have mentioned this zymotic disease, but do you know what is the general health of those districts, speaking in a very general way, and not asking for figures?—I cannot answer that question, because that would entail a very considerable amount of time and labour, and even what I have ascertained has entailed a very considerable amount of time and labour, which I could ill spare.

14,044. Why are the zymotic diseases selected?—Because they are considered to be the diseases which chiefly arise from or are affected by sewer emanations or emanations of that kind. I think the whole of the medical evidence for the City has gone to the effect that these diseases are at least the best test for sewage contamination.

14,045. Lung and throat diseases would not be a test of this question, would they?—I have seen throat diseases which I think have been caused or have been made very much worse by sewer emanations.

14,046. But you could not tell us, perhaps, whether the district is generally healthy?—I can give you the figures, if it is desired, but in a general way I can say that Greenwich and Woolwich are certainly healthy. Dartford is very healthy. Gravesend is very healthy, and Hoo singularly healthy. I think the death rate there is only about 14, and yet the zymotic death-rate was very much higher in the years 1856–65, when there was no sewage there, than in 1871–80 when it was there.

14,047. So you speak well of these districts generally, and especially well in regard to zymotic disease?—Yes; the death-rates from those diseases are very low.

14,048. (*Dr. de Chaumont.*) Supposing, with regard to the condition of the waterside population in those districts, it were suggested that the emanations from the river rose over them, and blew upon the land behind, what would you say?—I cannot imagine they would be so subtle; they must have been subtle in the extreme to have been blown over in that way, except with high winds. Such a supposition is altogether contrary to all that we know with regard to the spread of zymotic disease, except diphtheria, which is the only disease that we know to be carried any distance by the wind. There is not a single other disease that I believe to be carried by the wind. Small-pox has been stated to be carried by the wind, but this is entirely contrary to my experience.

14,049. But without supposing that the disease is carried in that way, if any emanations coming from the river were blown into the districts behind, they would increase to a certain extent the susceptibility of persons to disease, would they not?—I think the effect would diminish as the square of the distance increases, inasmuch as the emanation, whatever it was, would become mixed with such a large quantity of air in being carried away. The air is considered to oxidise all these injurious emanations more or less, and so would counteract them, and then, bearing in mind the mixing of the pure air with them to any great extent, I cannot imagine that that would increase either the susceptibility to disease or the injuriousness of the emanations.

14,050. (*Dr. Stevenson.*) Are those districts flat, or do they rise directly from the river?—They are mostly flat; there is rising ground at Erith and at Greenhithe somewhat.

14,051. Greenwich would not be rising ground?—Greenwich is not.

14,052. (*Sir John Coode.*) You are aware that, taking the first four districts in your Table 5, the mean population per acre is about 93, whereas in the second table the mean population per acre is 142. Would not that affect the result in the last column?—Undoubtedly it would to a certain extent; there is no question about it, but what I have done in Table 2 is that I have compared the death-rates in the same districts, or as nearly so as possible, irrespective of that.

14,053. But my question referred to Table 5?—In Table 5 it may have had something to do with it, because the density of population in Leather Market and St. Mary is greater by about 50 per cent.

14,054. (*Mr. Norman Bazalgette.*) Did you hear the evidence given by Dr. Collingridge with regard to certain outbreaks of typhoid on board the training ships which he attributed to the influence of the river?—I did.

15,055. What have you to say as those outbreaks?—In my opinion the river had nothing to do with them.

14,056. (*Chairman.*) What did Dr. Collingridge say?—He said generally that in some instances he believed that typhoid fever was caused by the condition of the ship, especially off Greenhithe, but that as regards the vessel which was moored in the midst of the sewage stream, he believed that the outbreak that took place arose from the extremely injurious state of the river. Now the singularity about it is this. In the whole of the epidemics which occurred on board this ship (two or three of which lasted for months, while the patients were kept in the ship); when the patients were taken out of the ship as soon as they got ill and the other residents were left in the polluted stream—in the "injurious" stream as Dr. Collingridge said,—the latter remained well. In fact the only way in which the disease was checked was by taking the sick away and leaving the healthy in the midst of the polluted stream, when those who were left in the ship remained perfectly well.

14,057. (*Mr. Norman Bazalgette.*) Leaving them in the infected area, so to speak?—Precisely. Then there is another matter as regards Dr. Collingridge's evidence. If the river were injurious as producing scarlet fever, undoubtedly that would be shown by the type. Now several of the cases of scarlet fever which occurred on board that ship are distinctly stated to have been of a very mild type indeed; and with regard to the typhoid fever it is admitted that the water supply was brought from the shore in a flexible hose. Now what is there to show that some polluted water did not get in. There is no question that if polluted water were drunk, and there were typhoid fever in London, some of those who drank it might get typhoid fever; and the whole of the evidence of Dr. Collingridge, as far as I have gone into it, was to that effect. The only evidence that he produced was that he himself when he was on board his yacht suffered from sickness and diarrhœa occasionally. None of the men were stated to have suffered, only he himself. Now I know if I do not get my meals regularly and am knocking about, I am very liable myself to get diarrhœa and also dyspepsia. I will not suggest that that was the case with Dr. Collingridge, but it would certainly have had that effect upon me.

14,058. (*Sir John Coode.*) You spoke of the water having been brought to the ship in a flexible hose. I suppose that water was connected with some company's service on shore?—Yes, no doubt.

14,059. Do you suggest that the water in this service was infected?—I do not say it was so. Dr. Collingridge said in his evidence it might have been so. He said that the water was analysed, and gave different analyses at different times.

14,060. But did you not speak of typhoid fever prevailing in London, and that that might have been the cause of the disease; I did not understand your answer otherwise?—I take Dr. Collingridge's own evidence; he stated the point in his evidence; I did not.

14,061. (*Dr. Stevenson.*) Do you mean to say, with regard to the flexible hose, that there might have been a leakage from the river into the hose?—Yes,

*Dr. J. W. Tripe.*

5 June 1883.

that is what might be suggested. Dr. Collingridge mentioned the matter.

14,062. (*Sir John Coode.*) But it would surely be the other way; the leakage would be from the hose into the river, seeing the head of pressure on the hose?—I may say at once that I abandon any theory of that kind.

14,063. (*Mr. Norman Bazalgette.*) I think you have some figures which show the death-rate on board the training ships during the years 1878–81, as compared to the normal or ordinary death-rate for all England?—Yes, the census of the ships gave 1,556 persons; there were 23 women and some children, and, as far as I could ascertain, the 56 would represent the women and children.

14,064. There are three ships, are there not?—There are five ships altogether.

14,065. (*Sir John Coode.*) You had better give them to the Commission separately?—I am not quite sure whether I can give you the precise spots where they lie, but I can give you the ships separately. The "Chichester" was not used at the time of the census as a dwelling-ship at all; but that and the "Arethusa" were taken together. The "Worcester" had been there, and the "Worcester" and the "Arethusa" were taken together for one batch of boys.

14,066. (*Mr. Beaumont Morice.*) They are at Greenhithe, I believe?—They are at Greenhithe; there were 209 there then. In the "Warspite" there were 195.

14,067. (*Sir John Coode.*) Where is she?—I think she was at Grays. In the "Cornwall" there were 226; she is off Woolwich. In the "Shaftesbury" there were 347, and in the "Exmouth" 579, making a total of 1,556. I believe the number of women and young children was about 56, leaving the 1,500 for the men and boys. Now there occurred in the "Exmouth" six deaths in the four years and one in the "Warspite."

14,068. (*Chairman.*) Taking the 579 in the "Exmouth," that would be three per mil.?—It is somewhat less than that, I think.

14,069. The average death-rate is about 20 per mil. per annum, is it not?—The death-rate at the ages from 10 to 20, which I will take as the average of those on board the ship, would be 6·72 per mil. for all England.

14,070. That is a state of comparative healthiness, is it not?—I am going to point that out. On the whole, in this case it was 4·2 in the ships for four years, as against 6·72, which is the general rate for all England.

14,071. Then there must be something exceptional there, which destroys the value of the comparison. You cannot attribute it to the sewer; you cannot say the sewer has made it healthy; but here are boys under regular discipline and thoroughly well fed; does not that account for it?—No doubt it takes it out of the average; but still I think that, taking the rate of mortality at 4·2 as against 6·72, the difference of 2·50 is in excess of the margin that you can fairly allow for the good food and the regular mode of life on board these ships. Then if you look at the causes of death they are chiefly acute rheumatism, pneumonia, and phthisis. There was one death from typhoid fever on board the "Warspite," and there was a death on board the "Cornwall," as to which I told you that in the year 1879 the sick were kept on board some months, and that it was only when the patients were moved out that the disease stopped. There was one death from scarlet fever and one only, and two deaths from typhoid fever out of 19 cases; the rest were acute rheumatism and phthisis.

14,072. (*Sir John Coode.*) Are we to gather from what you have told us that the continuance of the disease was due to overcrowding; that there were under the conditions too many individuals within a given area?—That is my belief, and also partly due to the infectious nature of typhoid fever, because typhoid fever is to a certain extent infectious.

14,073. Do you think the ship was well ventilated?—No, I do not.

(*Mr. Beaumont Morice.*) It was proved by the captains of the vessels that they had given up the use of the river water in consequence of the bad effects of it.

(*Witness.*) And very wisely too.

(*Mr. Beaumont Morice.*) They did not even use it for washing the decks.

(*Chairman.*) I was desirous of knowing whether the witness was contradicting those who know better than he does; do I understand you to say that he is contradicting them?

(*Mr. Beaumont Morice.*) Yes, he is. We have called witnesses to show that an outbreak occurred at the time when this water was being used.

14,074. (*Chairman to the witness.*) I do not understand you to say that if they were to use the water, but that if they were to drink it they might make themselves ill?—I have no doubt of it.

14,075. If they used it for washing clothes, or what not, would it have any effect?—I think that if they got the water upon their hands and put them in their mouth, or were thirsty and had a drink of it; in that kind of way it would decidedly prove injurious. I do not hesitate to say so.

14,076. (*Mr. Norman Bazalgette.*) Have you in the course of your investigations also looked, as the medical officer, at the Customs and Police Reports?—I have.

14,077. Do you find any remarks upon the health of the men under the charge of the Customs and Police medical officers?—No. Dr. Dickson, in his Report for the year 1880 on the health of the Custom House officers, says that the difference in the health and condition of the two divisions of the force, viz., of London and Gravesend, is the natural result of the great difference that exists in age, duties, and mode of life of the different officers employed, and he does not refer to any alleged injurious effect of the river.

14,078. I believe there is a passage in his Report for 1878 which is valuable?—Yes, he says at page 108 of his Report for 1878, "The proportion of "zymotic and febrile disease is, as usual, very "small."

14,079. Can you tell me how many men are engaged, on the average, in the Customs?—The table shows about 1,000 people; 860 are engaged on the river, 150 being employed as Thames Police, whom Dr. Browning spoke so strongly about.

14,080. Have you looked at the Reports of Mr. Holmes, the chief surgeon of the Thames Police?—I have.

14,081. What does he say about the health of the Thames Police?—He gives a list of the chief causes of death, which were pneumonia, rheumatism, and so on. He does not say a word in corroboration of what Dr. Browning says, although he is the chief surgeon, and Dr. Browning could not have reported to him what he said here, or else it would have appeared in that Report.

14,082. Is Mr. Holmes confirmed by Dr. Gayton's evidence before the Royal Commission?—Yes, Dr. Gayton gave evidence before the Royal Commission respecting small-pox and fever hospitals, and in reply to Question 2695 he said, "A well-arranged "deck" (this hospital ship was moored off Greenwich) "appears to afford plenty of opportunity for the "construction of an excellent ward, and well suited "in every respect for the treatment of small-pox "patients; and, as the amount of fresh air is "practically unlimited, it leaves little to be desired. "I think, moreover, that statistics in a few years will "show that cases treated on the Thames have done "infinitely better than on land"; that is Dr. Gayton's evidence; he gave his evidence last year, and referred to the ship in 1881.

(*Chairman.*) Of course there is fault found with the water up to Chiswick or Teddington Lock, for aught I know; but there is not much fault found with the water at Greenwich, as I understand.

(*Mr. Beaumont Morice.*) Not comparatively.

(*Witness.*) Now, Dr. Collingridge also stated that, with the exception of the typhoid fever outbreak, and the scarlet fever outbreak, the health generally of those on board the ships was very good.

14,083. (*Mr. Norman Bazalgette.*) Now, Dr. Browning, who gave the evidence you have quoted, was medical officer of health for Rotherhithe, was he not?—Yes, and he has published some Reports.

14,084. Have you examined his Reports? — I have.

14,085. What do you find in his Reports?—In his Report for 1880–81, or in that very year for which he produced certain statistics; he said, "We must re- "member that our neighbours and ourselves having "better food, drinking water, wages, lodgings, and "sanitary surroundings than most rural working "people, and breathing an atmosphere, which, thanks "to our river, park, and docks, is less polluted than "that of most cities, ought to be quite as successful "as country folks in raising young families." Now, they are not; they lose a large number of children. The reason is, that it is a densely crowded part; the children die, as I have shown you from the statistics of Liverpool, at a far more rapid rate under five years of age than they do in the country. Therefore, Dr. Browning should not have expected that living in the small houses that they do, and in courts and alleys, and with bad food many of them, they should be able to bring up their families in the same way as people can do in the country.

14,086. Do you find that the death-rate of Rotherhithe, as shown by Dr. Browning's own Reports, compares favourably with the death-rate of London?—Decidedly, I do.

(*Chairman.*) How high up the river are you going to take us.

(*Mr. Norman Bazalgette.*) This is Rotherhithe, my Lord. I am asking Dr. Tripe about this, because evidence has been given on the other side about it.

(*Chairman.*) If people give useless evidence upon the other side, what is the necessity of calling witnesses to contradict it.

(*Mr. Norman Bazalgette.*) After your expression of opinion, my Lord, I will not pursue it.

Cross-examined by Mr. Beaumont Morice.

14,087. With regard to the spot maps, which you have put in, I will take you first to that which you mentioned first, namely, Erith. Now, is it not the fact that along the foreshore, from the National School to the lower Ballast Wharf, there are very few houses?—There is not a very large number.

14,088. Upon the side fronting the river, of West Street, how many houses would you say there are?—It is some six months since I was there; there are two rows of houses, if I remember rightly.

14,089. But what I want is this; along that space from the National School to the lower Ballast Wharf, is it not nearly all marsh land? — I do not know whether it is marsh land; it is, with the exception of two or three rows of houses, open country.

14,090. Then there are very few houses, I may take it, upon the river side of West Street?—Not a large number.

14,091. Is that the case, taking the foreshore of Erith generally to Erith Pier?—It is crowded pretty well from the lower Ballast Wharf to the turn of High Street; it is a continuous row of houses from Cross Street.

14,092. Would you kindly follow me; is there not a succession of wharves along the foreshore, from the lower Ballast Wharf to Erith Pier?—Yes; there is a number of wharves, but on the other hand, part of it is quite open; you have wharves and gaps.

14,093. Taking the part further from the river, where you put the spots, and where you find the deaths have occurred, is not that a much more populated part than near the foreshore?—Than close to the foreshore, undoubtedly it is, but it varies considerably; Avenue Road, for instance, is not very much built upon, but some of the roads are.

14,094. Take Cross Street and High Street; are not those the populous parts? — Yes, and in High Street you will notice there is only one death.

14,095. Then I may take it that, according to this map, the parts where the deaths have occurred are the more populous parts of Erith?—To a certain extent, that is so.

14,096. I may take that as a fact, may I not?—Wheatley Terrace, which is much nearer to the river, where there were no deaths from zymotic diseases, is better populated than Manor Road, where a death from typhoid fever, and another from diphtheria, and a death from diarrhœa occurred.

14,097. Take Parkspring Place and Queen Street, are not those thickly populated with a great number of small houses?—They are.

14,098. (*Sir John Coode.*) When you say Wheatley Terrace is "better populated," do you mean inhabited by a better class of people, or that it is more thickly populated?—It is more thickly populated. I should say it is about the most densely populated part of the whole, and no deaths from zymotic diseases have occurred there.

14,099. And you put no deaths in the Bexley Road, between the "Wheatley Arms" and the spot by the Police Station?—There is one death between the Police Station and the river.

14,100. Are not the houses in the road fairly apart, and of better quality?—They are of better quality, and the same with the Queen's Road.

14,101. I may take it that the parts further from the river, where these deaths have occurred, are portions where the houses are small and densely populated?—No, certainly not, in Manor Road the houses are, as far as I remember, of a better class than some of those in the front.

14,102. But you told me that to a certain extent that was so in the case of High Street and Parkspring Place?—No doubt High Street is a very mixed street, poor and others together, but they are most of them of the tradesman class, and inhabited by what I should call comfortable people.

14,103. Now take the next, Greenwich?—The Greenwich frontage, I have already explained it, is to a great extent wharves.

14,104. (*Chairman.*) Can you say, speaking generally, whether the two or three cases in Erith that you have put, as you may call it, near the river, show a larger or smaller or equal per-centage to the population where they arise with the other cases which are more distant from the river? — I should say certainly that, taking the whole river frontage, the proportion is less. I do not mean that the population is less; I mean that the deaths, in proportion to the population, are less.

14,105. (*Mr. Beaumont Morice.*) Now, with regard to Greenwich; nearly the whole of that river frontage is wharf, is it not?—To a great extent; I have already said so in my examination-in-chief.

14,106. (*Chairman.*) The expression "close to the river" has been used once or twice before. I suppose there are very few places where the houses are actually upon the river, so that you could drop anything out of the window into the river; there is always a road or something between, is there not?—Yes, Greenhithe is the nearest, I think; that is, closest to the river.

14,107. (*Mr. Beaumont Morice.*) You have very few spots upon the riverside of Chester Street, have you?—No, although some of those streets comprise a very low class of houses.

14,108. I see you have "waste land" upon the right-hand side?—Yes, and to the left, a short distance off, is the hospital; I have not taken that in.

*Dr. J. W. Tripe.*

5 June 1883.

14,109. Is there any high ground at the back of this map?—Yes, there is Greenwich Park, and there is also rather a dense population both in the old Woolwich Road and Northumberland Street; those are decidedly densely populated. Chester Street is also densely populated, and so, in fact, are the whole of those streets.

14,110. Now, I will ask you, between Chester Street and the river, is there anything like a correspondingly dense population to what there is at the back of Chester Street?—Yes; that part of Marlborough Street between Chester Street and the river, the whole of Bennett Street, Newcastle Street, Kitson Terrace, is densely populated. Little Marlborough Street is a little dirty court, where you would have thought there would always have been some disease of the kind, and there is not one instance of a zymotic death.

14,111. Then you have the Stone Yard, and then you come to the Lime Kilns, which take up a large portion of the space?—The map shows that there is nothing kept back.

14,112. But there is a large space taken up by works of some kind?—There is.

14,113. Would not that rather interfere with your theory as to the deaths being greater away from the river than near it in a similar population?—There is no population there to suffer along the wharves.

14,114. But I was not talking about the wharves, but of Chester Street?—But there have been no deaths at all in four years between Chester Street and the river, where the population is.

14,115. But you would not say that there is anything like as dense a population there as there is behind?—Yes, I do. As far as the streets themselves are concerned, the streets at the back of Chester Street seem to be more respectable than those streets which are nearest the river.

14,116. Could you give me any ratio as to the population behind Chester Street to that between it and the Thames?—Scarcely; but I should say there might be two as regards the population between Chester Street and the river, and three behind, but there is a difficulty about the census, so I could not give it accurately.

14,117. Now, with regard to the Woolwich map, the Woolwich river frontage is nearly all either wharves or workshops, or works of some kind, is it not; that is to say, there are gasworks at each end, to begin with; they cover a large space of ground, do they not?—They do.

14,118. Then there are all the workshops in the square near the steamboat pier?—Yes, that is so.

14,119. Then there are one or two large spaces near Market Hill; do not those different works which you have mentioned take a large part of the space between the High Street and the river?—They occupy some space.

(*Chairman.*) Take Rodney Street. Rodney Street is not on the river, do you say?

(*Mr. Beaumont Morice.*) I have not said that it is immediately upon the river.

14,120. (*Chairman to the witness.*) How far back would it be from the river?—It would be about 70 feet back.

14,121. (*Chairman.*) Is not that close enough to be poisoned? How near would you put it?—Of course, I can see there is one street close.

14,122. But I am taking the whole body?—In Nile Street, which runs to the river, there is no death at all. Then I would point out strongly that, as regards Rope Yard Rails and Cannon Row, all of which are identical as regards the class of houses, the spot maps show that the bulk of the disease is situated rather at the back than in the part near the river.

14,123. (*Mr. Beaumont Morice.*) After all, none of this map is far off the river?—Very little of this map is more than a quarter of a mile off the river.

14,124. Then I see you have seven spots on this part between the High Street and the river. Now what I want to ask you is this:—Can you give us any idea of the population between High Street and the river, compared to that between High Street and the rest of the map?—I should say there would be one-third the number in that part next the river to two-thirds behind.

14,125. (*Chairman.*) Are there twice as many on the south side of High Street as there are upon the north side?—I should think so.

14,126. Do you know Woolwich well?—I have been down there three or four times, for the purpose of coming to a fair estimate.

14,127. Do you know that the density of Woolwich is one-fourth that of London?—I cannot say precisely what is is.

14,128. Have you been through all these streets behind High Street?—Yes; I took the whole block from Powis Street, and followed Powis Street right out to the end.

14,129. I am not talking of Powis Street?—I went into every street, court, and alley upon the plans, and I know every site. I adopted every reasonable means of coming to a fair conclusion.

14,130. I am sure you have done that. But what I mean is, looking at the admitted density of the population of Woolwich, do you mean to say, that taking all the marks which appear upon your spot map between High Street and the river frontage, there are only twice as many people living behind High Street as there are between High Street and the river?—I think so; including High Street, of course.

14,131. Which side of High Street, both sides?—I took both sides.

14,132. (*Chairman.*) Which do you put High Street in?—I put High Street in the river area.

(*Chairman.*) Is not this really too microscopic?

14,133. (*Mr. Beaumont Morice.*) I will not press it any further. (*To the witness.*) With regard to the density of population, does scarlet fever increase with any reference to that?—Yes, scarlet fever, I should say, especially.

14,134. Do you know of any comparison between the death-rate from scarlet fever in Woolwich and London?—Yes; Greenwich and Woolwich were 1·03 for the 10 years. I should expect that the Woolwich rate would be far below that of London.

14,135. But do you know as a fact whether it is?—(*After referring.*) In Woolwich, for scarlet fever from the year 1871 to 1880 the rate was ·61, and in London it was ·60.

14,136. So that they are practically the same?—Yes. That is taken from Dr. Corfield's tables.

14,137. Do you know the difference between the density of population in the one and the density of population in the other?—Yes, I can give you that. The density of population for Woolwich is 11·8, and for London 46·9.

14,138. I will not ask you about Rotherhithe; but you have stated that, oddly enough, the densest places seemed to suffer the least. Are you still of that opinion?—I do not think I said so; if I did say so, I did not mean it.

14,139. You do not think so?—No, certainly not.

14,140. Then you think the densest places are the worst?—The densest places, as a rule. I have stated it very plainly. As regards Liverpool, you have 363 deaths under five years of age to 100 deaths from zymotic disease in the healthy districts, where the population is less than one to the acre.

14,141. You mentioned Liverpool. You know that Liverpool has a very high death-rate?—Yes, some years ago, viz., in 1874, it was 32, but in 1882 it was only 26·5 per 1,000.

14,142. Do you know how they get their water supply?—No, I do not.

14,143. Do you know that they have drained all the cesspools below Liverpool?—I do not know anything of the drainage of Liverpool, or of the water supply.

14,144. You have not been able to ascertain the ordinary cases of disease and illnesses which have

taken place in those parts where you have taken the death-rate?—I have not worked it out. It would require to be gone into at such a length that I did not attempt it.

14,145. So you have only taken the death-rate?—That is so. I can give it you, if you want it, out of some books, but I have not got it out myself. I have only the Registrar-General's Returns.

14,146. You have told us that your theory with regard to the better state of the houses near the river is that the air from the river blows through them, or blows the bad smells away; that is always the case, is it not, near a river, or near the sea?—Yes. I believe that Glasgow is pretty nearly the same as London, and that the river there is rather worse than it is near London.

14,147. That would always follow, would it not, near a large stream, or near the sea?—The River Liffey, at Dublin, is a very important exception. All round the Liffey, in Dublin, diseases of this class are very rife indeed, and a very high rate of mortality indeed prevails.

14,148. (*Chairman.*) Is that so, indeed; where the tide comes up?—It is in Dublin itself.

14,149. But the Liffey is a very narrow stream?—It is.

14,150. And filthy?—Yes, it is filthier than the Thames.

14,151. (*Sir John Coode.*) The river walls are high in Dublin, and, therefore, the river is not so open to the influence of the currents of air?—That is so.

14,152. (*Mr. Beaumont Morice.*) You mentioned it as an exception; is it not the fact that the river itself, however large or small it be, is in a filthy condition?—It is filthy in the extreme. It is not a fair illustration to compare the Liffey with the Thames in any way whatever.

14,153. Therefore, if you had a river larger than the Liffey, which is in a filthy condition, similar results might follow?—I am not prepared to say any "ifs" at all. I would rather content myself with what I know.

14,154. (*Chairman.*) I suppose there are parts of the Liffey within the city where the sewage is not oxygenated at all; are there not?—I should think there are.

14,155. (*Mr. Beaumont Morice.*) You stated that when the sewage was taken away from the district the death-rate decreased?—Yes, I say that that is a fact.

14,156. Do you know that, since the sewage has been taken away from Upper London, the death-rate has decreased?—It has decreased all over London. It has not been confined to the vicinity of the Thames.

14,157. But in the vicinity of the Thames it has decreased?—It has decreased. I stated that the decrease in London had been 17·5 per cent. in the 10 years from 1871 to 1880, taking London all through.

14,158. As a fact, the death-rate has decreased?—Yes, it has.

14,159. And when the sewage is taken into a district at first the death-rate had increased?—No, the death-rates have decreased in the district below the outfalls as compared with the 10 years from 1856 to 1865. It was higher in 1856–65 than it was in 1871–80.

14,160. But when it was first taken down, before your data, did it not increase?—There is a gap in the data between 1866 and 1871. That I cannot give you, because I have not got it.

14,161. Those are the very data that I want. Do you know when the sewage was taken down?—Yes, I remember very well. I was born in London. I have shot Old London Bridge, and I remember the Thames very well. In fact, I often cross at Gravesend and take a bath there, because it is a very pleasant bath at Gravesend.

14,162. Have you anything to show whether the death-rate increased when first the sewage was taken into the lower districts?—No, I do not think there is any relation between the two things, to tell you the truth.

14,163. But you have no such data?—I have none.

14,164. Would not the state of health of the lower districts, even after the sewage had been taken down, depend upon the seasons?—No doubt, and therefore I say, I do not attribute much importance to those statistics, extending, as they do, over an immense area, but these spot maps I look upon as most important, and the statistics in my Table 1 as next in value.

14,165. Then you do not attach any importance to the statistics upon the point?—I do not attach any great importance to the statistics of the Registrar's districts upon the point. I think that Dr. Corfield's tables and mine upon the point are of equal value, and I leave it to the Commission to say what that value is.

(*Chairman.*) What do you wish to show?

(*Mr. Beaumont Morice.*) That at first there was an increase in the death-rate in the low districts, though it may have decreased subsequently?

(*Chairman.*) And that the present decrease is due to this, that the mischief is still going on, but that it is countervailed by the wet seasons?

(*Witness.*) If that were so, the only way I could understand it would be that when the sewage was first taken down it killed off so many that it left so many less to be killed afterwards.

(*Mr. Beaumont Morice.*) Last year and the year before were very wet years, and there were not the amount of complaints that there were previously.

(*Chairman.*) The witness does not know that?

(*Witness.*) No, I do not.

(*Sir John Coode to Mr. Beaumont Morice.*) When you say "when the sewage was first taken down," what do you mean? for one year, two years, or three years; because it is rather indefinite.

(*Mr. Beaumont Morice.*) I meant for the first two or three years, without tying the witness to any particular year; but the witness cannot give us any data at all.

(*Witness.*) 1877, I think, was rather a healthy year?

14,166. (*Mr. Beaumont Morice.*) There are a great many cases of poor people who have illnesses, but who do not die, which would not come under your notice?—No doubt, people may have illnesses and not die. I cannot say anything about the number of cases of disease. I have already explained that I could not get at the cases of disease, but if river had any influence whatever, it would necessarily show itself in the death rate.

14,167. Would that death rate show all the cases of poor people who die?—Yes, because I traced out the deaths from zymotic disease in these districts. I followed them out in the hospitals and everywhere I could.

14,168. I suppose a sick person might be taken to Guy's Hospital?—Guy's Hospital does not take in infectious cases. But I have been to all the hospitals for infectious diseases, and I went to the Greenwich Infirmary. I got at all those who had died there from this district.

14,169. There are hospitals which take the infectious cases of the district?—Yes, there are.

14,170. Did you go to such hospitals?—I did.

14,171. Did you enquire what cases had been brought from Greenwich or Rotherhithe?—Yes, from those particular areas, but from nowhere else. To every one of those hospitals I have been to ascertain the deaths of people from those particular areas.

14,172. You not only ascertained those who died in houses and the local hospitals coming from there, but those who died in hospitals elsewhere coming from there?—I did.

14,173. (*Sir John Coode.*) You think you have gone far enough afield?—Yes, I do.

14,174. (*Mr. Beaumont Morice.*) You said that Dr. Corfield had not distributed those who had died elsewhere into different parishes?—Yes.

*Dr. J. W. Tripe.*

5 June 1883.

14,175. If he had done as you suggest he ought to have done, would it not rather have told against the case of those whom you represent by making the death rate greater along the riverine districts?—Not the riverine districts alone, they all would have suffered equally. I would give you some idea as to the extent. In Stepney, first of all——

14,176. But that is rather too far up for us?—Shall I take Greenwich.

14,177. Yes, take Greenwich?—There were nearly 300 deaths put in with the Greenwich mortality which ought not to have been there, and as regards some of the other districts there were nearly the same number left out that ought to have been there.

14,178. Why do you say they should not be in Greenwich?—Because people died in the "Atlas" ship and in the small-pox hospital in Greenwich, whose illness did not originate in Greenwich, and who did not reside there before death.

14,179. Take the Northfleet district?—But Northfleet has nothing at all to do with the metropolis.

14,180. Could you give me the figures of Northfleet?—No, I cannot, because it is a sub-district.

14,181. Let me ask the question generally. If Dr. Corfield had distributed the deaths in parishes, as you say he ought to have done—— ?—No, excuse me, I did not say he ought to have done.

14,182. Upon your principle then, I will say, would it not have made the death rate in the riverine districts very much greater?—No doubt it would, but it would have made the death rate in the adjoining districts also greater, they would have shared in it to a certain extent.

14,183. Did I understand you to say something about the death rate amongst the Jews?—No, I did not say it, but their death rate is singularly small from zymotic diseases.

14,184 I thought you accounted for the high death rate in Rotherhithe by reference to them?—No, I never referred to them at all.

14,185. With regard to the outbreak of fever in those training ships, do you know whether it is at all attributable to the water brought from the shore?—Dr. Collingridge went into that question; and he had some little doubt in the matter, and there were two analyses of the water given which differed rather considerably. The first analysis, as far as my recollection goes, showed a larger amount of impurity than the second.

14,186. Have you any knowledge of your own about it?—I have none.

14,187. Do you know the pumping at the Essex Waterworks on the Essex shore?—Yes, I do.

14,188. Do you know that before the waterworks were established the wells contained a good deal of salt?—No, I do not. I do not know anything about the analyses.

Re-examined by Mr. Norman Bazalgette.

14,189. Your spot maps, I think you told me, were compiled for the years 1878 to 1881, were they not?—Yes.

14,190. Therefore they do not include last year, the wet year, when my learned friend says that few complaints were made of the river?—No.

14,191. Do they include the year 1881, when we had an exceptionally hot summer?—Yes, they do.

14,192. Do you know that in July 1881 a temperature of 97° was reached?—It was 96·5 at my house.

14,193. At any rate, the maps include that exceptionally unfavourable year, and they do not include that exceptionally favourable year that my learned friend has mentioned?—That is so. I made them out as fairly as I could.

14,194. Now about the margin of the river. Can you tell how the density of population of the river along the margin compares with the density of population back from the river?—In most instances I should say the density was greater near the river, inasmuch as the houses are comparatively small, and the rooms are small and fully occupied, so that the cubic space for each person, which is the chief matter, in my opinion, with reference to the overcrowding, would be greater in the houses near the river than farther away.

14,195. When you have wharves and warehouses, do you generally find a narrow street, part of which is occupied by small dwellings?—Very frequently.

14,196. But, generally speaking, along the margin of a river, do you find that the rooms are small and the houses are small, and much over-crowding in consequence?—Yes, certainly.

14,197. Upon the whole, do you find the margin of the river enjoys a singular immunity from death from zymotic disease?—Yes, certainly I do.

The witness withdrew.

Mr. John Holmes Groves called; examined by Mr. Norman Bazalgette.

*Mr. J. H. Groves.*

14,198. You are a Greenwich waterman, I believe?—I am.

14,199. Were you employed by Messrs. Law and Chatterton to take soundings of the river?—I was.

14,200. Where were you on the 16th October last?—On the north bank in Erith Rands.

14,201. Who was with you?—A young man of the name of Gadsdon.

14,202. Anybody else?—Yes, a young gentleman belonging to the Board.

14,203. What were you doing; were you in a boat?—No, I was upon the river bank.

14,204. What were you doing?—I was laying out sections to take soundings across the river; we were driving the pegs.

14,205. Did you see a boat containing two men with one of the Corporation floats?—I did.

14,206. What do you remember about it?—I made the remark to Mr. Gadsdon that I thought, according to the position of the boat, she must be attached to the float.

14,207. Was the tide flowing up?—Yes, the tide was flowing up.

14,208. Was there a strong east-south-east wind blowing?—Yes, there was a strong east-south-east wind blowing at the time.

14,209. Did you actually see that the float was attached to the boat?—I could not swear that. I only went by the position of the boat. My opinion was that, if the float was not attached to the boat, the velocity of the wind would have taken the boat right away from the float altogether.

14,210. When you saw them were they moving together?—Both were moving together.

14,211. (*Chairman.*) Had they not got any oars out, or anything?—Nothing of the kind.

14,212. (*Sir John Coode.*) About what was the height of the gunwale of the boat above the water surface, speaking generally?—About 18 inches.

(*Chairman.*) Did the boats with the floats have any drag out to drag over the water, that is to say, in order to prevent them going faster than the floats?

(*Mr. Beaumont Morice.*) No, there were no drags out, nothing of the kind.

14,213. (*Mr. Norman Bazalgette to the witness.*) Do you remember the 19th October last?—I do.

14,214. (*Chairman.*) Well, what happened at last. Did the boat and the float go out of sight?—They went out of sight.

14,215. Up the river?—Yes, up the river.

14,216. Was the tide flowing at the time?—Yes, the tide was flowing.

14,217. And the wind blowing rather up the river than not?—Yes, there was an east-south-east wind blowing up the river.

14,218. When did they get out of sight?—About a quarter of an hour after I saw them.

14,219. (*Mr. Norman Bazalgette.*) Did you see the float tilted at the time?—I could not swear that.

14,220. (*Sir John Coode.*) Were the boat and the float in the same relative position to each other for the whole of the quarter of an hour while they were in sight?—They were.

14,221. About what distance was the boat from the float?—It might have been about two feet.

14,222. (*Chairman.*) You could not see any attachment?—I could not.

14,223. How came they not to blow on to the Essex shore, because an east-south-east wind would blow them on to the Essex shore?—When I saw them they were to the south of mid-channel.

14,224. Did they blow over to your side?—No, they went to mid-channel; as they came up towards Erith.

14,225. Where were you?—I was on the north bank.

14,226. But in what part of the river?—I was upon Erith Rands, below Erith.

14,227. (*Sir John Coode.*) Did you see them upon the bank, following the boat?—No.

14,228. Then, as the boat got up the river with the float, you could not tell that the boat and the float were constantly about two feet from each other; but what you mean, I suppose, is that when they passed you they were about two feet apart?—Yes, as far as I could judge, when they passed me.

14,229. (*Chairman.*) Was the float ahead of the boat, or after, or abeam, or what?—It was ahead of the boat.

14,230. (*Mr. Norman Bazalgette.*) Was the boat fouling the float?—No.

14,231. But how was that?—The boat was going astern up the river, and the float was fastened to the bow of the boat.

14,232. (*Chairman.*) If they had not been fastened together, they would have parted; that is your notion?—They would have parted.

14,233. (*Mr. Norman Bazalgette.*) Do you remember the 19th of October last?—Yes.

14,234. Where were you then?—I was in my boat.

14,235. At what time in the morning was this?—6.15 a.m.

14,236. (*Chairman.*) Going back to the 16th, where were the men; seated in the boat?—They were sitting down in the boat, I believe; they were out of my view.

14,237. Had they no oars out at all?—There were no oars out at all.

14,238. They were out of your view?—The men were; they were sitting down in the boat.

14,239. (*Sir John Coode.*) If they were out of your view, they must have been lying down, I presume, unless they were sitting in the bottom of the boat?—In the bottom of the boat, I presume, they were.

14,240. (*Mr. Norman Bazalgette.*) Now you told us you were out about a quarter-past six in the morning of the 19th of October?—Yes.

14,241. (*Chairman.*) What time of the day was it that you have been speaking of?—It was in the morning: it was light.

14,242. And you could have been seen?—Yes, I could have been seen.

14,243. (*Mr. Norman Bazalgette.*) Then Gadsdon was with you in your own boat when you were out, was he not?—Yes.

14,244. What was the tide doing?—The tide was ebbing.

14,245. And how was the wind?—The wind was south-east.

14,246. What did you observe?—I observed one of the Corporation floats with a boat, the float being attached to the boat.

14,247. (*Sir John Coode.*) Then it would be just daylight; it would not be broad daylight, would it, at that time?—Yes, it was quite broad daylight.

14,248. (*Chairman.*) Where were you then?—I was in my own boat on the river.

14,249. How far were you from them?—I was about 20 yards, perhaps.

14,250. (*Sir John Coode.*) Were you there for the purpose of following them and watching what they were doing?—Not then; I was on my road down to Erith.

14,251. (*Mr. Norman Bazalgette.*) The sun rose on that morning at 6.32; it was a quarter of an hour before sunrise. (*To the witness.*) Did you actually see the float attached to the boat on this occasion?—I did see the float fastened to the boat on that occasion.

14,252. What was it fastened with?—A small line.

14,253. Was it ahead of the boat or behind the boat?—It was ahead of the boat.

14,254. Was the boat stopped by the wind?—It was.

14,255. Did you recognise the men on board?—I did.

14,256. Who were they? What were their names?—Mears and Whiting.

14,257. To go to another occasion; do you remember the 29th of October last?—I do.

14,258. Have you some memoranda there?—I have (*producing a pocket book*).

14,259. Did you take some memoranda at the time?—I did.

(*Chairman.*) Would you allow me to see them?—(*The same was handed to the noble Chairman.*)

14,260. These memoranda do not notice that a float was attached to the boat?—No.

14,261. This is only a memorandum, is it, of what you did upon that day?—That is all.

14,262. You have not mentioned that they had got their floats in a suspicious way, have you?—Not upon that occasion.

14,263. Did you upon any occasion?—No, I never noted anything of that kind.

14,264. You were only making memoranda of your own work?—Yes, that was so.

14,265. (*Mr. Norman Bazalgette.*) Now, upon the 29th October at 5.30 a.m., where were you?—I was on Greenwich Pier.

14,266. Where had you just come from?—I had just come off the water.

14,267. What did you see?—As I was walking on Greenwich Pier, I saw a boat nearing Greenwich Pier, and as it was nearing the pier I found it had a float attached to it, and two men rowed alongside Greenwich Pier and made the boat fast along with the float.

14,268. Who were the two men?—Tanner and Long.

14,269. Did you see the float actually attached?—I did.

14,270. What was it attached by; a rope?—A small line.

14,271. When they made their boat fast to Greenwich Pier, what did they do?—Went on shore.

14,272. How long did they remain on shore?—Twenty-five minutes.

14,273. What did they do then?—They came back, got into the boat, and towed the float out into mid-stream, and let go the float, and then let it drop down the river.

14,274. Having been on shore 25 minutes?—Yes.

14,275. (*Chairman.*) You knew this was wrong, I suppose, did you not?—I knew it was quite wrong.

14,276. When did you mention it to the gentlemen who have called you now; to Mr. Chatterton or anybody else?—I used to make a report every week.

14,277. Of such matters as these?—Yes, of such things as these.

14,278. Do you mean to say that you reported this in November, because you must have reported this nearly at the time it happened. To whom did you actually report it?—To Mr. Chatterton.

*Mr. I. H. Groves.*

5 June 1883.

14,279. But these men have been called as witnesses. Mears, I think, has been called.

(*Mr. Lumley Smith.*) No, he was not actually called, but his name was frequently mentioned.

(*Chairman.*) You can call him if you like.

(*Mr. Lumley Smith.*) If your Lordship pleases.

(*Mr. Norman Bazalgette.*) Mr. Peregrine Birch was cross-examined as to this.

(*Sir John Coode.*) He was cross-examined in some considerable detail, if I remember rightly.

(*Mr. Norman Bazalgette.*) At question 9793 you will find he was asked, "Were Mears and Whiting employed upon October the 17th at 6.15 a.m.?" To which he replied, "Yes, they were."

(*Chairman.*) Was he asked anything about this labour-saving practice of fastening the float to the boat?

14,280. (*Mr. Norman Bazalgette.*) This was in the cross-examination of Mr. Birch, and Mr. Birch was asked this question, "During the time the experi- "ments were going on, was any information ever "given to you by my learned friend's clients of any "misfeasance on the part of the men?" To which he replied, "Certainly not." (*To the witness.*) Now, where were you on October 30th?—In my boat.

14,281. Had you anyone with you?—There were four other men.

14,282. Whereabouts were you?—I was going up what we call Tripcock Reach, on my way home.

14,283. Which side of the river?—To the south of mid-channel.

14,284. What did you come upon?—We came upon a boat very close to the shore.

14,285. What was in the boat?—Two men were in the boat. As we came close to the boat, I could see that there was a float very close to the boat. We went past the boat first, and I thought I would be sure and be correct to see who the men were, so I put back with my boat, and when we put back alongside this boat both men were asleep, and the float in a sort of lying down position, as if it were touching the ground.

14,286. It was stationary, at any rate?—Yes.

14,287. Did you see it attached to the boat?—Yes, I did.

14,288. (*Sir John Coode.*) If the float was stationary, the boat must have been stationary too?—It was.

14,289. Then, if the boat was aground, it acted as a mooring to the boat?—It was in an entirely slack tide.

14,290. (*Mr. Norman Bazalgette.*) You say the men were asleep, did they have a sail over them?—They had a sail over them.

14,291. Did you speak to them as you went by?—Yes, we called out, and when we got no answer we listened a minute, and put back in order that we might be really correct to know who they were.

14,292. (*Sir John Coode.*) Did you ascertain who they were?—Yes; directly I heard the voice of the men, I knew who they were.

Cross-examined by Mr. Lumley Smith.

14,293. Your name is Groves, is it?—It is.

14,294. What are you by profession?—I am a licensed waterman.

14,295. I do not quite understand this; were you in the service of the Metropolitan Board of Works?—Yes, at the time.

14,296. You were regularly engaged by them, were you?—I was not regularly engaged. I had been engaged, on and off, 19 years.

14,297. But at that particular time, the 16th and 19th October, am I to take it that all through October, or about that time, you were engaged by the Metropolitan Board of Works?—I was.

14,298. What were you engaged to do?—My first engagement was to watch the float operations of the Corporation.

14,299. That is what you were set to do, to watch the float operations of the Corporation; when was it that you were ordered to that first?—I never made a note of it.

14,300. Did you begin making notes immediately you were engaged?—I did not.

14,301. How soon did you begin?—Only when I saw anything wrong on the part of the men employed on behalf of the Corporation.

14,302. However, you were to watch the floats and to report anything that you saw wrong?—Yes, I was.

14,303. What is this black book; is it a memorandum of what you saw from day to day?—Yes, it is.

14,304. I see you saw something wrong upon the 17th; when does it begin, the 17th of what month?—I do not know.

14,305. Cannot you tell from memory what month this is, because the book begins at 1 p.m. upon the 17th, and I want to know what month that is?—I quite forget.

14,306. Just look at the book (*handing a book to the witness*), and tell me what month it is; is that in October, or when. (*The witness referred to the book.*) Can you tell me when you were first paid, would that give you any idea?—No; I do not remember.

14,307. You were to watch the floats—here are a couple of pictures of floats—are they pictures of floats that you put in this book here?—To the best of my ability, I did them.

14,308. And this you put upon the title page, so that you knew exactly what you had to look for?—Yes, I did.

14,309. You were told what you had to look for, and you made these pictures?—I saw them myself upon Greenwich Pier.

14,310. The "Toby" was Mr. Birch's tug, was it not?—Yes, it was.

14,311. You had general instructions, had you, to put down anything you saw wrong?—No.

14,312. Were you instructed to report anything that you thought wrong?—Not at all.

14,313. What then?—To say anything about the floating operations.

14,314. What did Mr. Chatterton want to know?—He wanted to know if the men employed acted anything that was wrong.

14,315. I see this entry in your book, "At 1 p.m. "on the 17th, the Corporation tug 'Toby' came along- "side at Greenwich Pier with three new tide floats, "8" (something I cannot read), "made of pitch pine, "13 feet long. Watermen and gentlemen appeared "to be quarrelling on board the tug"; that was the first thing you saw that you thought wrong; what did you put that down for—their coming alongside with new floats and quarrelling—what did you put that down for; did Mr. Chatterton want to know that?—No.

14,316. Then why did you put down about Mr. Birch and his friends quarrelling on board the tug; can you tell me why you put that down?—I cannot tell you.

14,317. Was not it because you were to put down everything that attracted your notice about the floats?—No.

14,318. Was that put in to accompany the picture of the floats?—No.

14,319. The next memorandum I see is, "18th, "Corporation tug 'Toby' abreast of Greenwich Pier." This must have been in September. "19th. Went "down to Crossness, fixed tide gauge upon the jetty "end—saw the tug 'Toby' come up to Greenwich— "no floating operations on that day—strong wind "from north-east. Harbour master with steam "launch." Then, as I understand, the 17th was the day the float operations began. Do you remember the

day the "Toby" came up with the three new tide floats and the men quarrelled; was that the first day they went in, I want to know?—I do not remember.

14,320. Do not you know whether it was September or October you began watching the floats?—I think it must have been in September.

14,321. Then you watched all through September; there is an entry on the 24th?—Yes.

14,322. I think you have memoranda about the floats right through that month; all these entries refer, do they not, to the floats; that is so, is it not?—I am sure I do not know.

14,323. (*Sir John Coode.*) Do you understand the question?—Yes.

14,324. (*Mr. Lumley Smith.*) All these entries refer, do they not, to the Corporation float experiments?—Yes, they do.

14,325. (*Sir John Coode.*) Do they refer to anything else besides the Corporation floats?—I think you will see a few entries about fish or anything like that.

14,326. (*Mr. Lumley Smith.*) You mention the fish, that was with a view to this inquiry, was it; were all these things in the book things that you were to tell Mr. Chatterton?—Not the whole of them.

14,327. What was there that he was not interested in?—He is only interested in regard to the float operations.

14,328. What about the fish that you were telling us of; you are not a fish merchant, are you?—No.

14,329. What was that about the fish?—To test the water.

14,330. For the purpose of this inquiry?—Yes.

14,331. Then everything in this book is for the purpose of advancing the Board of Works case in this inquiry?—Yes, that is so.

14,332. I see some of the floats you follow down, and you have down the hours and minutes at which they went down all the way. When you followed the floats you made the entries carefully?—Yes, I did.

14,333. Now we come to the 16th of October; first of all, I suppose you have shown this to Mr. Chatterton; is there any entry at all about any one of these four occasions upon which you saw the float being treated as you describe. There is nothing in this book, I take it, about it; is there?—I used to make a report once a week of whatever I saw.

14,334. Is there anything in this book which is at all a memorandum of the occasions which you have been telling us about to-day?—Yes, there is.

14,335. Will you point it out to me, please, taking first of all, the 16th of October?—That is the one (*handing the book to the learned counsel*).

14,336. "Erith Rands, 16th, 1 p.m. Boat driving "up with flood tide, wind east-south-east strong, "watermen's boat fast to float No. 4." Now then I see you make a note of the number, these floats were all numbered, were they not?—I believe the Corporation floats were all numbered.

14,337. (*Sir John Coode.*) How do you know this was No. 4 float; was the "No. 4" on the float visible to the naked eye, how did you know it was not No. 3, or No. 2?—After we had done our work, I passed this float up at Blackwall, and then I saw the number.

14,338. (*Mr. Lumley Smith.*) Anybody could see the number; the number is a big number, is it not?—Yes, it is a large number.

14,339. Is it stuck upon the float?—Yes, it is.

14,340. And upon the boat too, is it not?—No, it is not.

14,341. Are you sure of that?—Yes, I am sure.

(*Mr. Baldwin Latham.*) They had a painted flag in the front of the boat, with the number upon it corresponding with the number of the float, and upon every pier a notice was posted about them.

14,342. (*Mr. Lumley Smith to the witness.*) There was a big number upon the boat, upon the flag?—Yes, upon the flag or upon a tin flag.

14,343. So that anybody could read it?—Yes, it represented a flag.

14,344. Another was on the 16th October, was it not?—Yes.

14,345. At what time in the day?—1 p.m.

14,346. Where were the men who were in the boat then; was this memorandum made at the time?—Yes, it was.

14,347. Just tell me why you have put the 16th of October in the book several pages after the 1st of November, and several pages after the 29th of October?—I do not know the reason why. I did it so irregularly.

14,348. But I find entries taken on the 29th of October, and the 25th of October, and then comes the 16th of October; how came you to put that in two pages after the 29th?—The book is not in a regular way in any part of it.

14,349. (*Sir John Coode.*) Were those notes made day by day as the events occurred?—Yes, they were.

14,350. That is to say, what happened to-day you would make a note of this evening?—Yes, or at the time.

14,351. But some time during the day upon which the occurrences took place?—Yes, at some time of the day.

14,352. (*Mr. Lumley Smith.*) Will you explain to me why you do not go regularly through the book; if this page was blank, then why should you have stuck in the 16th after a lot of blank pages?—I do not know why I should have done it.

(*Sir John Coode.*) He says he made them day by day; if that is so, it would be a mere irregularity.

(*Mr. Lumley Smith.*) Then it comes to be a question how far this is to be relied upon.

14,353. (*Sir John Coode to the witness.*) Can you tell me why you did not put in the 16th after the 15th?—I cannot say.

14,354. Can you say positively that this was made day by day?—It was made at the time.

14,355. That what occurred to-day was not entered to-morrow or the day after to-morrow?—What occurred to-day is entered immediately after it occurred; upon the day it occurred.

14,356. Did you do so in every instance?—Yes, in every instance.

14,357. Are you quite sure of that?—I am quite sure of that.

14,358. (*Mr. Lumley Smith.*) Now upon this 29th of October, what time of day would it be when you saw this float brought to Greenwich Pier?—5.30 a.m. I think it was.

14,359. What sort of float was it that was brought?—It was a small float; one of the bucket floats as they used to call them.

14,360. Not one of the bigger floats?—No, not one of the big floats.

14,361. Which of the other occasions were big floats?—The two other occasions were the large floats.

14,362. Which were those; the 16th and 19th October?—The 16th, and 19th, and the 30th.

14,363. That is three occasions; were they all large floats?—Yes.

14,364. What was this fish you mentioned? You put some eels in, did you not?—Yes, I did.

14,365. And the eels died, did they not?—Yes, they did.

14,366. (*Sir John Coode.*) Were they in a healthy state when you first got them?—Yes, they were.

14,367. Where did you get them from?—From one of the Dutch vessels at Billingsgate, lying off Billingsgate Market.

14,368. (*Mr. Lumley Smith.*) Before I pass from the floats, can you give me the number of the one that you saw Mears and Whiting in?—I cannot.

14,369. Now on the 30th of October at Tripcock Reach, when the two men came to the shore in a boat asleep, what was the number of that one?—I do not know. It had no number.

*Mr. J. H. Groves.*
5 June 1883.

14,370. (*Sir John Coode.*) Was this one of the boats belonging to the Corporation?—Yes, it was.

14,371. How do you know that, if it had no number on?—No number on the float.

14,372. If there was no number on the float or on the boat, how did you know it was a Corporation boat?—I knew the men.

14,373. Upon this particular occasion?—Yes, upon this particular occasion.

Re-examined by Mr. Norman Bazalgette.

14,374. It is suggested to me that you are mistaken in saying that that was float No. 4; are you quite certain of it, or are you just speaking from memory.

(*Sir John Coode.*) It is important to know whether this was a Corporation float.

14,375. (*Mr. Norman Bazalgette.*) I think you told us that you identified the number of the float afterwards at Blackwall?—I passed the float at Blackwall, and I must have taken that one to be the one I saw attached to the boat.

14,376. Are you certain that the one you saw at Blackwall was the one you saw attached to the boat?—I cannot say for certain.

14,377. Do you recollect putting some eels at Greenwich in a box about six feet under the water for Mr. Chatterton?—I do.

14,378. Did you let them float down the river with the tide?—I did.

14,379. Where did they go to?—Down to Erith.

14,380. Did you then let them come back again?—I did, past the southern and northern outfall.

14,381. Did you let them come back upon the flood?—I did.

14,382. How did they get on?—They were all very well when I reached Greenwich.

14,383. Did the eels look any the worse for their voyage?—I think there was an improvement in them.

14,384. (*Sir John Coode.*) Did you clear the box out at Greenwich?—No, I kept them there.

14,385. What became of them after that?—They remained there.

14,386. But for how long?—They remained there over two months.

14,387. You moored the box to something?—I made it fast properly to a mooring place.

14,388. (*Mr. Norman Bazalgette.*) You left the box there for two months, did you?—I did.

14,389. And the eels remained alive the whole time?—Yes, they did.

14,390. Were they the same eels as had made the voyage past the two outfalls?—Yes.

14,391. What became of the eels eventually?—Some person or other took them away, or something broke the box up.

14,392. Were those the eels that you were speaking of just now, when you said that they died?—No, they are not the same ones. I got a fresh lot for them; they were put in at Erith.

14,393. Where were they put in at Erith?—At the "Castalia."

14,394. How long were they there?—They were there about seven weeks.

14,395. Did they die after the seven weeks?—Yes.

14,396. They were seven weeks off the "Castalia," and then they died?—Yes, they were off the "Castalia."

14,397. (*Sir John Coode.*) Where is the "Castalia"?—Just below Erith.

The witness withdrew.

*Mr. C. H. W. Grundtvig.*

Mr. Conrad Henry Walter Grundtvig called; examined by Mr. Norman Bazalgette.

14,398. You are a pupil of Messrs. Law & Chatterton?—I am.

14,399. And a student at the Institution of Civil Engineers?—I am.

14,400. Were you upon the river upon the 16th of October?—I was.

14,401. What were you doing?—I was putting in pegs upon the north shore for the purpose of taking sections.

14,402. What did you see while you were doing that?—I saw a boat passing up the river just above, in a line with a place called Anchor Bay. A boat was going up the river stern foremost, with a float attached to the bow.

14,403. (*Sir John Coode.*) What boat was that?—The boat I could identify as a Corporation boat, first on account of the float, and secondly on account of the red flag which she had at the stern.

14,404. Was there any number on the flag?—I could not see that; the flag was lying down in the boat.

14,405. (*Mr. Norman Bazalgette.*) Did you see the line by which the thing was attached?—I could not.

14,406. For what reason did you think it was attached?—The float was slightly inclined.

14,407. You were out again on the 19th, were you not?—I was not.

(*Sir John Coode.*) It does not necessarily follow that because the float was inclined it was attached to the boat.

14,408. (*Mr. Norman Bazalgette.*) Did you upon the same occasion observe another float?—I did.

14,409. What was the other float doing as compared with the one that you say was being towed?—When I observed the former the boat was going up first broadside and the oars were out; the boat kept on whirling about, so the men had to use their oars in order to keep back to the float; the float of course was going up the river after them; in the latter case the float and the boat kept close together the whole way for a period of about a quarter of an hour while I watched them.

14,410. (*Sir John Coode.*) Did you follow the boat up the river further?—No. I was on Coldharbour Point, and I could see them as they swept round the point.

14,411. (*Mr. Norman Bazalgette.*) Which of the floats was going the fastest?—The second one, I should think.

Cross-examined by Mr. Lumley Smith.

14,412. When you were out on the 16th October, what time of the day was it?—About one o'clock.

14,413. Who was with you?—The waterman, Groves, and another man named Gadsdon.

14,414. What is the occasion that you speak of when you mention two floats?—The 16th October.

14,415. That is the only one?—Yes.

14,416. Let me see if I understand. First of all the thing was slightly inclined, and you also say you could see some other float?—Yes.

14,417. In one case the float was going up the river about as fast as the boat, and in the other case the boat seemed to go up fastest?—In the first case the boat went up at some distance from the float, and

in the second case I followed the second boat up for a period of a quarter of an hour, and the float and the boat kept quite close together; I could hardly see daylight between the float and the boat.

14,418. Was that the float that you were speaking of when you said it was inclined, or was it a different one altogether?—It was the second float that was inclined.

14,419. First you say you saw one that was slightly inclined?—No, that was the second float.

14,420. How many did you see altogether on that day?—Two.

14,421. The one which was slightly inclined was the one which you watched; was that the one which kept close to the boat or not?—It was the one which kept close to the boat which was inclined. *Mr. C. H. W. Grundtvig.* 5 June 1883.

14,422. That is your reason for thinking it was attached, though you saw no line attaching it?—No, only the wind was blowing very strongly, and it was broad daylight.

14,423. Still this was one o'clock in the day, and the men were not asleep?—No, they were not.

The witness withdrew.

JAMES EDWARD PETRIE called; examined by Mr. NORMAN BAZALGETTE.

14,424. You are a Greenwich waterman, are you not?—I am. *J. E. Petrie.*

14,425. What were you doing on the night of Sunday, 15th October?—I was watching No. 6 float.

14,426. What time were you watching her?—I commenced at 10 minutes past 9 on the Sunday evening, and proceeded to Bow Creek; it was low water then. Then when the tide turned we went up the river.

14,427. Were you near Millwall Pier at 12.50, that is to say, at 10 minutes to 1 on Monday morning?—Yes.

14,428. Was the tide going up?—It was.

14,429. In what direction was the wind?—East-north-east.

14,430. Did you see the men who were in charge of No. 6 float do anything?—Yes.

14,431. What were they doing?—They were fast to the float; it blew a strong wind.

14,432. Whereabouts was it fastened to the boat?—It was fastened to the main thwart of the boat.

14,433. You saw the line that fastened it to the boat, did you?—Yes, there are five thwarts to the boat, and it was fastened to the middle one.

14,434. Was the boat dragging the float?—Yes.

14,435. Did you see the number of the float?—Yes.

14,436. How far did you go up with them?—I went as far as Fulham.

14,437. What happened to it; did the tide turn?—Yes.

14,438. Did you go back with them?—At 4.40 the tide turned.

14,439. Did you go back with them?—I stopped till the tide turned, and then I came back with them.

14,440. How far did you go back with them?—As far as Greenwich. I accompanied the float through Battersea bridge, and then it became daylight.

14,441. (*Sir John Coode.*) Were you near to them all this time?—I was close to them. I had to be close to them on account of putting down every place the float passed, so I had to keep close to them all the time, and when we came through Battersea bridge, there being a strong wind and tide, they had to slip the float from the boat, because there was such a current that very likely the float might have knocked a hole in the boat.

14,442. (*Mr. Norman Bazalgette.*) And you say it was daylight there?—Yes, it was.

14,443. Do you know what the names of the men who were on board?—Yes.

14,444. What were their names?—One was named Long and the other Hampshire.

14,445. Did you make a note at the time of what you saw?—I did.

14,446. Have you got that with you?—I have a note of all the driving; I did not make a note of the other circumstances.

14,447. (*Sir John Coode.*) Are those the identical notes that you made at the time?—No, they are not.

14,448. Where is the original?—With regard to the sheet I had on the Sunday night, and early Monday morning, it rained so all night that it would be impossible for anybody to make out anything from it, except myself, so I had to copy it myself, and these (*producing some slips*) were copied from it the next day.

14,449. When the float was going up stream, was it hurried up by the wind?—Yes, the boat would hurry it up, because the boat was athwart the tide and the wind would have great effect upon it.

14,450. Did you have to use your sculls all the time, to keep your boat back to the float?—Yes, I had.

14,451. Coming down with the tide, was the float retarded by the wind?—No, coming down with the tide, the float would come much faster than the boat; we had to row sharp to keep pace with the float then.

Cross-examined by Mr. LUMLEY SMITH.

14,452. How many days had you been out watching this float; was this the first day you went out?—No, it was not.

14,453. How long had you been out?—I think something like a fortnight, to the best of my recollection.

14,454. Were you always watching No. 6 float, or were you watching some of the others?—Yes; I think No. 6 float I was watching for a fortnight.

14,455. Were there the same men in the Corporation boat?—Two of them were, but there was one changed sometimes.

14,456. There was always on board one man during the whole time.

(*Sir John Coode.*) I understand two out of the three had been there the whole time.

(*Witness.*) There were three men out of four; there were two in the boat at a time, and Long and Tanner, I think, were the two men at first, and Hampshire, I think, was put in Tanner's place.

14,457. How many men were there in the boat at one time?—Two in their boat, but only one in our boat.

14,458. (*Mr. Lumley Smith.*) You were following the float and putting down the time at which it passed each place?—Yes.

14,459. And that you did every day?—Yes, I did.

14,460. And night too?—Yes; I did not do it night and day. I was relieved the same as the rest.

14,461. But whenever you were there you did it?—Yes, I did.

14,462. And they knew you were doing that?—Yes.

14,463. They knew you were watching them?—Yes, no doubt they did.

14,464. This you wrote out the next day; you did not write it out that night, but you wrote it out the next day?—Yes.

14,465. Why did you not make a note of having seen this boat fastened to the float; why did not you

*Mr. J. H. Groves.*
5 June 1883.

14,370. (*Sir John Coode.*) Was this one of the boats belonging to the Corporation?—Yes, it was.

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Re-examined by Mr. Norman Bazalgette.

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14,396. They were seven weeks off the "Castalia," and then they died?—Yes, they were off the "Castalia."

14,397. (*Sir John Coode.*) Where is the "Castalia"?—Just below Erith.

The witness withdrew.

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Mr. Conrad Henry Walter Grundtvig called; examined by Mr. Norman Bazalgette.

14,398. You are a pupil of Messrs. Law & Chatterton?—I am.

14,399. And a student at the Institution of Civil Engineers?—I am.

14,400. Were you upon the river upon the 16th of October?—I was.

14,401. What were you doing?—I was putting in pegs upon the north shore for the purpose of taking sections.

14,402. What did you see while you were doing that?—I saw a boat passing up the river just above, in a line with a place called Anchor Bay. A boat was going up the river stern foremost, with a float attached to the bow.

14,403. (*Sir John Coode.*) What boat was that?—The boat I could identify as a Corporation boat, first on account of the float, and secondly on account of the red flag which she had at the stern.

14,404. Was there any number on the flag?—I could not see that; the flag was lying down in the boat.

14,405. (*Mr. Norman Bazalgette.*) Did you see the line by which the thing was attached?—I could not.

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14,407. You were out again on the 19th, were you not?—I was not.

(*Sir John Coode.*) It does not necessarily follow that because the float was inclined it was attached to the boat.

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14,409. What was the other float doing as compared with the one that you say was being towed?—When I observed the former the boat was going up first broadside and the oars were out; the boat kept on whirling about, so the men had to use their oars in order to keep back to the float; the float of course was going up the river after them; in the latter case the float and the boat kept close together the whole way for a period of about a quarter of an hour while I watched them.

14,410. (*Sir John Coode.*) Did you follow the boat up the river further?—No. I was on Coldharbour Point, and I could see them as they swept round the point.

14,411. (*Mr. Norman Bazalgette.*) Which of the floats was going the fastest?—The second one, I should think.

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14,417. In one case the float was going up the river about as fast as the boat, and in the other case the boat seemed to go up fastest?—In the first case the boat went up at some distance from the float, and

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14,421. The one which was slightly inclined was the one which you watched; was that the one which kept close to the boat or not?—It was the one which kept close to the boat which was inclined. *Mr. C. H. W. Grundtvig.* 5 June 1883.

14,422. That is your reason for thinking it was attached, though you saw no line attaching it?—No, only the wind was blowing very strongly, and it was broad daylight.

14,423. Still this was one o'clock in the day, and the men were not asleep?—No, they were not.

The witness withdrew.

James Edward Petrie called; examined by Mr. Norman Bazalgette.

14,424. You are a Greenwich waterman, are you not?—I am. *J. E. Petrie.*

14,425. What were you doing on the night of Sunday, 15th October?—I was watching No. 6 float.

14,426. What time were you watching her?—I commenced at 10 minutes past 9 on the Sunday evening, and proceeded to Bow Creek; it was low water then. Then when the tide turned we went up the river.

14,427. Were you near Millwall Pier at 12.50, that is to say, at 10 minutes to 1 on Monday morning?—Yes.

14,428. Was the tide going up?—It was.

14,429. In what direction was the wind?—East-north-east.

14,430. Did you see the men who were in charge of No. 6 float do anything?—Yes.

14,431. What were they doing?—They were fast to the float; it blew a strong wind.

14,432. Whereabouts was it fastened to the boat?—It was fastened to the main thwart of the boat.

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14,436. How far did you go up with them?—I went as far as Fulham.

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14,441. (*Sir John Coode.*) Were you near to them all this time?—I was close to them. I had to be close to them on account of putting down every place the float passed, so I had to keep close to them all the time, and when we came through Battersea bridge, there being a strong wind and tide, they had to slip the float from the boat, because there was such a current that very likely the float might have knocked a hole in the boat.

14,442. (*Mr. Norman Bazalgette.*) And you say it was daylight there?—Yes, it was.

14,443. Do you know what the names of the men who were on board?—Yes.

14,444. What were their names?—One was named Long and the other Hampshire.

14,445. Did you make a note at the time of what you saw?—I did.

14,446. Have you got that with you?—I have a note of all the driving; I did not make a note of the other circumstances.

14,447. (*Sir John Coode.*) Are those the identical notes that you made at the time?—No, they are not.

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14,449. When the float was going up stream, was it hurried up by the wind?—Yes, the boat would hurry it up, because the boat was athwart the tide and the wind would have great effect upon it.

14,450. Did you have to use your sculls all the time, to keep your boat back to the float?—Yes, I had.

14,451. Coming down with the tide, was the float retarded by the wind?—No, coming down with the tide, the float would come much faster than the boat; we had to row sharp to keep pace with the float then.

Cross-examined by Mr. Lumley Smith.

14,452. How many days had you been out watching this float; was this the first day you went out?—No, it was not.

14,453. How long had you been out?—I think something like a fortnight, to the best of my recollection.

14,454. Were you always watching No. 6 float, or were you watching some of the others?—Yes; I think No. 6 float I was watching for a fortnight.

14,455. Were there the same men in the Corporation boat?—Two of them were, but there was one changed sometimes.

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(*Sir John Coode.*) I understand two out of the three had been there the whole time.

(*Witness.*) There were three men out of four; there were two in the boat at a time, and Long and Tanner, I think, were the two men at first, and Hampshire, I think, was put in Tanner's place.

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14,461. But whenever you were there you did it?—Yes, I did.

14,462. And they knew you were doing that?—Yes.

14,463. They knew you were watching them?—Yes, no doubt they did.

14,464. This you wrote out the next day; you did not write it out that night, but you wrote it out the next day?—Yes.

14,465. Why did you not make a note of having seen this boat fastened to the float; why did not you

*J. E. Petrie.*

5 June 1883.

write that down?—I thought it was not required, because it was one thing continually, the whole flood tide, I might say.

14,466. They always did it every day, did they?—No, I do not say that.

14,467. What do you mean?—I say the whole flood-tide.

14,468. Then why did you not put down upon your note that the men tied the float to the boat the whole of that flood-tide?—I could recollect it.

14,469. But you were to report it to the Metropolitan Board of Works?—I was.

14,470. Then why did not you put that down?—Because I could recollect it.

14,471. (*Sir John Coode.*) Did you report weekly to the Board?—I used to report when I had done my drive to Mr. Groves, and then Mr. Groves used to send the report in to the Board, I think, every week.

14,472. If I understand you accurately, you made these observations on 14 days previously to the 16th of October; had you previously observed any irregularity in the way of making the floats fast to the boat?—No.

14,473. Previously to that the thing had gone on correctly?—Yes, it had gone on properly.

(*Sir John Coode.*) I should like to know what these weekly reports that were sent in contained.

(*Mr. Norman Bazalgette handed in a report made by Groves to Mr. Chatterton.*)

14,474. (*Sir John Coode.*) This appears to be notes of the times at which the floats passed certain points. Then I see, "12.50 a.m. Waterman's boat "made fast to float at Bottle Point, and kept his float "fast up to Fulham Dock." (*To the witness.*) You sent your report to Groves, and Groves sent it in to Messrs. Law and Chatterton?—Yes.

Cross-examined by Mr. Beaumont Morice.

14,475. Is this your writing?—No, that is Groves' writing.

14,476. (*Sir John Coode.*) Over what period did your observations extend altogether. You have told us of a fortnight previously to these dates; how long after this did you watch these boats; up to about what date?—Up to about the 20th of October.

14,477. Beginning in September, or when did you begin?—I do not think we began till the beginning of October.

14,478. Then it was for about a month?—We began, I think, a month after the others had begun.

14,479. For a month altogether?—Yes.

14,480. For the first fortnight you observed no irregularity, but upon this particular day you say you did?—Yes.

14,481. Did you observe anything irregular after that?—No, I did not.

Re-examined by Mr. Norman Bazalgette.

14,482. When you observed this about the float you made a report to Groves upon the subject within 12 hours after you had observed it?—Yes, I did.

14,483. And then Groves sent in his report at the end of the week?—I think on the following Saturday.

The witness withdrew.

Arthur James Avent called; examined by Mr. Norman Bazalgette.

*A. J. Avent.*

14,484. You are a Greenwich waterman, I believe?—I am.

14,485. Were you with Groves and Gadsdon upon the 30th October?—I was.

14,486. Did you see a float made fast to a boat?—Yes.

14,487. Upon what day was that?—The 30th October.

14,488. Who were the men that you were with?—Groves and Gadsdon.

14,489. Who were the men you saw?—Taylor and Clements. They were the men that were in the boat that was fast to the float.

Cross-examined by Mr. Lumley Smith.

14,490. You only speak to one occasion, I believe?—Yes, only to one occasion.

14,491. The two men in the boat were Taylor and Clements. What time of the day was it?—About a quarter past five in the morning. I was just come off duty.

14,492. Where were you?—I was rowing up just by Tripcock Point.

14,493. Was it light enough to see?—Yes, there was light enough to see.

14,494. Were the men asleep in the boat?—Yes, they were asleep. We went by and hailed them, but they made no answer, and we went back to the boat, and they jumped up from under a sail.

14,495. What number of float was it?—I do not think there was any number upon the float.

14,496. (*Sir John Coode.*) Did you make any remark to them about having caught them napping?—Yes.

14,497. What did they say?—They jumped up and said something. I do not remember the remark they made, but it was not a very nice one.

14,498. But the sun did not rise till 7 o'clock, and this was a quarter past 5?—Yes, it was.

14,499. Do you mean to say you saw this float actually tied on?—Yes.

14,500. Could you see it?—Yes, there was a line attached to the float.

14,501. You did see the line attached to the float?—Yes, I did.

14,502. And tied on to the boat?—Yes, to the boat's thwart.

14,503. Every one of you could see it?—Yes, every one of us.

14,504. Then what you could see all the rest of the men in the boat could see?—Yes.

The witness withdrew.

Adjourned to to-morrow at half-past 12 o'clock.

# THIRTY-EIGHTH DAY.

## Wednesday, 6th June 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, Esq., F.R.S., *Secretary*.

Dr. ANDREW WISE called in; examined by Mr. NORMAN BAZALGETTE.

*Dr. A. Wise.*
6 June 1883.

14,505. You live at 207, Burrage Road, Plumstead, and are a physician and surgeon?—I am.

14,506. Do you attend, and have you ever since the opening of the Crossness outfalls attended, the persons employed by the Metropolitan Board of Works who reside at Crossness?—I have.

14,507. What do you say as to their health compared to that of people who live in adjoining places?—It is quite as good as that of people residing elsewhere.

14,508. Have you been able to trace any diseases there to the influence of sewage?—Not any.

14,509. Have you found a larger proportion of diarrhœa or of zymotic disease prevalent there than elsewhere?—I have not.

14,510. Have there been any cases of typhoid fever since the outfalls were opened?—There has not been one case on the works to the best of my recollection.

14,511. How many men are employed there?—50 men are employed there, but the whole 50 do not reside there, some of the men are married and have children, and the population of the place itself is about 150.

14,512. That is including women and children, is it not?—Yes.

14,513. (*Chairman.*) Do you attend them for the Metropolitan Board of Works?—I do.

14,514. (*Mr. Norman Bazalgette.*) I presume the children include a certain number under five years of age?—Yes, they do.

14,515. As the result of your general practice at Plumstead, what do you say as to the prevalence of zymotic diseases there?—I do not think they prevail to any larger extent than in other places.

14,516. Can you tell me whether you have formed any general conclusions, as the result of your practice at Crossness and Plumstead as to the influence of the discharge of the sewage into the river upon the health of the neighbourhood?—I think it is nil.

14,517. Do you ever smell evil smells in Plumstead?—I do.

14,518. What do you attribute them to?—To the factories on the banks.

14,519. I believe some of the cottages you attend at Crossness are close to the banks of the river?—They are.

14,520. When you attend patients at those cottages have you ever been able to perceive any smell from the river itself?—At the houses themselves on the works there is no smell of sewage: that is to say, not in the houses.

Cross-examined by Mr. WEBSTER.

14,521. Where do you actually reside?—At Burrage Road, Plumstead.

14,522. Is this evidence of yours as to there being no greater amount of zymotic disease here than in other places based upon any tables or statistics which you have prepared?—Not any.

14,523. It is a general impression, is it not?—It is a general impression.

14,524. When you say zymotic disease is not more in this district than in others, what are you taking as the other districts with which you compare it?—I have had experience in other places.

14,525. Do you mean in other parts away from London?—In other parts of England.

14,526. Is this evidence based upon any number per 1,000 or anything of that kind?—No.

14,527. It is a general impression merely: it is not more than that?—It is a general impression.

14,528. Now about these which my learned friend Mr. Bazalgette calls "evil smells," what is it that you do smell there, do you know?—I am really not an expert in smells, but I should say it is an unpleasant smell: I cannot describe it; I do not think it is the smell of sewage.

14,529. Beyond saying they are evil smells, you cannot say that they are of any particular description?—No.

14,530. Do you trace any particular diseases to these smells?—No.

14,531. You have come and told us this generally, and I have no doubt you believe in it, but you have no statistics or tables of any kind with regard to any class of disease in your district or in any other district?—I am medical officer of the district, and I return to the board of guardians each year the figures, but I have not the figures here.

14,532. I ask you, have you any statistics to put before the Commission, or any facts as to the death rate or the disease rate either in your district or in the adjoining districts?—No, I have not.

14,533. (*Sir John Coode.*) Do you attend the people employed at both outfalls?—No, only at Crossness.

14,534. (*Mr. Webster.*) What is the area over which you consider that you have personal knowledge, where does it begin, and where does it go to?—It begins at Woolwich and goes to Belvedere from Shooter's Hill to the river bank.

14,535. How far down is Belvedere?—Belvedere is the adjoining parish to Plumstead.

14,536. Does it go below Crossness?—It stands rather above Crossness.

14,537. What is the highest point upon the river of your district?—It adjoins Crossness.

14,538. You said Woolwich just now, as I understood?—Woolwich is one of the boundaries.

14,539. What is the boundary lower down?—Erith.

14,540. Do I understand Erith is in your district?—It is not.

14,541. What parish is the most easterly parish there is in your district?—Belvedere.

14,542. Where is Belvedere with regard to Crossness?—It is above it.

*Dr. A. Wise.*
6 June 1883.

14,543. How much above it?—It stands upon the heights above.

14,544. (*Chairman.*) What do you mean by "above" it, in elevation or higher up the river?

(*Mr. Webster.*) In elevation?

(*Witness.*) It is in a direct line with it; it is not higher up the river.

14,545. (*Mr. Webster.*) Where is it with regard to Erith?—It stands above Abbey Wood.

14,546. Is Belvedere upon the river bank?—No, it is not; it stands back above Crossness.

14,547. How far back does it stand?—I should think a couple of miles.

14,548. Belvedere is a couple of miles back from Crossness, upon what we call the higher land, and then I want to know what is the nearest point upon the river banks to the outfall of which you have personal knowledge. Is there anything nearer than Woolwich?—No, none.

14,549. (*Chairman.*) I thought you said you attended the men at Crossness?—I did.

14,550. That is at the outfall itself?—Yes.

14,551. (*Mr. Webster.*) Your evidence relates to the people at the outfall?—Yes.

14,552. And not with regard to zymotic disease specially, but as to disease or illness generally?—Generally.

14,553. But your evidence with regard to zymotic disease and things of that kind is confined to the people at the outfall?—It is.

14,554. (*Chairman.*) I did not understand that you said it was confined to them, but that you said generally that you found an absence of zymotic disease there?—Yes, but it was given with regard to those people specially.

14,555. (*Colonel Ewart.*) How many people have you to attend to?—150 residing at the reservoir itself.

14,556. How far is that from where the sewage is actually discharged?—I should say less than a quarter of a mile; an eighth of a mile at the outside, I should say.

14,557. If you were called upon to recommend a site for additional labourers' cottages to be constructed, would you place them near the outfall or would you place them at some little distance off?—I should certainly not select the site of the outfall for fear of anything in the future occurring, but I do not think from past experience that there is any reason to expect it.

Re-examined by Mr. Norman Bazalgette.

14,558. Though you have no figures to lay before the Commission, do you think that your visits to the Crossness outfall have enabled you to form a pretty good opinion as to the presence or absence of zymotic disease there?—I think they have.

14,559. (*Chairman.*) You attend these establishments, I may say?—Yes, I do.

14,560. At the cost of the Metropolitan Board of Works?—Yes.

14,561. Why is it that they undertake the doctoring of their servants, do you know at all?—I should think from their being liable to accident.

14,562. Is that so; do they meet with accidents?—I have not had many cases of accident, but I may say also there have been months without my ever having been sent for to go down to see anybody at all.

14,563. (*Mr. Norman Bazalgette.*) As a matter of fact, I believe Belvedere is the adjoining parish to Erith?—Yes.

14,564. Is it upon high ground?—Yes.

14,565. (*Mr. Webster.*) But it is inland, is it not?—It is inland.

14,566. (*Sir John Coode.*) Did you say how long you had been in attendance upon the Board's officers?—Ever since the opening of the outfall; within a few months at any rate.

14,567. (*Dr. Stevenson.*) If there were any cases of ordinary illness amongst the children, would you be called upon to attend them in your official capacity?—No, I should not. I am simply appointed to attend the men, and not the children.

14,568. (*Chairman.*) I should like to ask you a question upon that. I suppose the children occasionally there are ill?—Yes, they are.

14,569. And I suppose the parents would in all probability employ you?—I have heard that in some cases they have had a doctor from Erith, but, as a rule, I have attended them.

14,570. (*Dr. Stevenson.*) Supposing cases of ordinary illness did occur among the people there, and that you were not called in, such cases as typhoid or diarrhœa or diphtheria, do you think you would hear of those cases?—I am sure I should, the superintendent there would report them to me at once.

14,571. Are you frequently at the works?—I have gone several months without going down there, owing to the absence of illness.

The witness withdrew.

(*Chairman to Mr. Bazalgette.*) Sir John Coode told me yesterday a thing I did not know, which was that the Crossness sewage did not fall into the river at all, but is conducted under the water of the river and finds its way through the bottom.

(*Mr. Law.*) That is so; it issues below low-water mark.

(*Chairman.*) So that it always has a covering of water over it when it comes out?

(*Mr. Law.*) It is never discharged visibly.

(*Sir John Coode to Mr. Law.*) About what depth of water is there over the pipes at low spring tides?

(*Mr. Law.*) At low spring tides I should say the opening was just covered, but we will give you the exact dimensions.

(*Sir John Coode.*) How does the water manage to get out?

(*Mr. Law.*) By the increased head from the pressure of the sewage in the reservoirs.

(*Sir John Coode.*) But it does not get covered with gravel or anything of that kind?

(*Mr. Law.*) No.

(*Sir John Coode.*) There is strength enough to wash that away.

(*Mr. Law.*) Yes; and, the bed of the river being deeper below it, it is never silted up.

(*Sir John Coode.*) About how much do the mouths of the pipes stand up above the bed of the river?

(*Mr. Law.*) I do not know, but we can give you a section which will show that.

(*Chairman.*) That is not the case at the Barking outfall, is it?

(*Mr. Law.*) No, you can see it at low water; the sewage outfall is covered at high water; you can see the sewage discharging there.

(*Chairman.*) Could not you have the same arrangement there as you have at Crossness?

(*Mr. Law.*) I do not know why it was not carried out there, but it has not been.

(*Chairman.*) It would be an improvement, I suppose, would it not?

(*Mr. Law.*) Scarcely, I think; it could be done.

(*Chairman.*) Surely it would be all the better, would it not?

(*Mr. Law.*) The beach there is very short, and when the reservoirs are enlarged I doubt whether the sewage will then be discharged after the water has fallen below the level of the outfalls.

(*Chairman.*) But you will not answer my question.

(*Mr. Law.*) Under those circumstances, it would not be an improvement.

(*Chairman.*) It would be neutral, neither better nor worse.

(*Mr. Law.*) Yes.

(*Sir John Coode.*) But, under present circumstances, do not you consider the mode of discharging at Crossness is preferable to that at Barking? 6 June 1883.

(*Mr. Law.*) Yes, under present circumstances.

Dr. JOHN DIXON called in; examined by Mr. NORMAN BAZALGETTE. *Dr. J. Dixon.*

14,572. You live at 133, Jamaica Road, Bermondsey?—I do.

14,573. And you are an M.D., L.R.C.P., London, and M.R.C.S., England, and L.S.A.?—Yes.

14,574. I believe you are also Medical Officer of Health for the Bermondsey District?—Yes, I am.

14,575. And you have been so for the last six or seven years?—Yes, for seven years.

14,576. Previously to that, what position did you hold?—I was poor law medical officer for 14 years.

14,577. (*Sir John Coode.*) Were you medical officer for the same district?—For the waterside district of Bermondsey; the parish was then divided into three districts, of which the one by the water side is by far the largest.

(*Chairman.*) What are we doing in Bermondsey?

(*Mr. Norman Bazalgette.*) It is a river side district, and I think it is one of the districts about which Dr. Corfield spoke; it also adjoins Rotherhithe.

(*Chairman.*) I thought we had agreed that Rotherhithe we need not trouble ourselves about. But, as Sir John Coode says, as you have brought the witness, you may take it shortly.

14,578. (*Sir John Coode to the witness.*) Over what length of river frontage would the district extend to which you have referred as having been medical officer for?—I was parochial surgeon for 14 years for the waterside district before I was medical officer of health for the whole parish.

14,579. You had a riverside district had you not?—Yes.

14,580. What extent was that?—391 acres. It was half a mile in frontage to the river, including the whole of the parish which adjoins the Thames.

14,581. (*Mr. Norman Bazalgette.*) I believe, as a matter of fact, your practice in Bermondsey has extended over a period of 25 years?—It has.

14,582. First of all, can you tell me whether in parts of the district near the river there is any evidence of any injurious effects on health from the sewage in the Thames?—None that I know of.

14,583. What is the character of the riverside population; is the density of the population as great there as in the districts further back?—It is rather more dense, if anything, because the houses are very old and they are smaller.

14,584. (*Sir John Coode.*) You are speaking of the district immediately on the river bank, are you not?—I should say this was so some years ago, because some of the houses have been pulled down and warehouses have been built; but I still say that the houses near the riverside are smaller and older.

14,585. (*Mr. Norman Bazalgette.*) And as regards the social position of the residents in those houses, are they the better-to-do classes or the poorer classes?—They are the poorer classes of the waterside neighbourhood; there are equally poor classes in the inland district.

14,586. Is typhoid fever in excess of the average, and is there any excess of zymotic disease?—Typhoid fever has been below the average for several years. In the last year we had only half the proportion of enteric fever which existed in London.

14,587. Is the proportion of children in this riverside district high as compared with the rate of population?—I cannot say for the particular district of the riverside, but for the whole parish we have more than our proper proportion of children, and that proportion is the largest in the St. James's district which includes the riverside. The effect of this is, that we have more than our fair proportion of deaths from measles and whooping cough, and in some years from scarlet fever and infantile diarrhœa; and our zymotic rate may be higher than that of London, although we have less fever.

14,588. Have you ever seen any signs of sewage at Bermondsey or smelt it?—No, I have not.

Cross-examined by Mr. WEBSTER.

14,589. The river frontage is almost entirely warehouses and graving docks and shipping, is it not?—It always has been, as far as the river frontage is concerned, but there are poor houses upon the opposite side of the Bermondsey wall within a few feet. All through Rotherhithe there are not private houses by the side of the river.

14,590. You have spoken of the average of enteric fever being half that of London; over what area is that?—Over the whole parish, the area of Bermondsey is 626 acres.

14,591. Just tell us roughly the boundaries; what is the southern boundary?—The Rotherhithe New Road.

14,592. Blue Anchor Road, does it go down there?—No, Blue Anchor Road is down the middle of it. The River Thames, West Lane, Southwark Park Road, Galley Wall Road, Rotherhithe New Road, Rolls Road, near Old Kent Road, Long Lane, Crosby Row, Snow's Fields, Artillery Street, and Dockhead are the boundaries.

14,593. Does that give me the main boundaries?—Yes.

14,594. That goes nearly two miles and a half from the river, does it not?—No, the parish is only one mile across.

14,595. And what length would you judge the average at, roughly?—A mile and a half, I should say, in length, and less than a mile in breadth.

14,596. This is the average over the 626 acres which you have given us?—Yes, we have only had nine cases of enteric fever in the 12 months.

14,597. Including all the part round Blue Anchor Road and Rotherhithe New Road and all that part?—Yes.

14,598. Have you any actual statistics from the river distinct?—I should like to know what you cal "the river distinct."

14,599. I would say the quarter of a square mile which is upon the margin of the river?—I can tell you this, that in no street near the river were there any cases of typhoid fever last year; those are the statistics with regard to the streets near the river.

14,600. My question is, have any statistics with regard to the strip next the river?—I have.

14,601. What are they?—There were only two cases of fever in the neighbourhood, and it was doubtful whether they were enteric fever or not, one being a child two years old, which was under the charge of a man who attends people for 6*d.* a time, and therefore not very likely to pay very much attention to the case; and the other was a child 12 years, also very doubtful; if that doubt were well founded, there was no case of enteric fever near the river last year.

14,602. Is Saint Olave's, Southwark, in Bermondsey?—Do you speak of the parish or union? Bermondsey parish is in Saint Olave's Union, and Saint Olave's parish forms a part of that union.

14,603. What is the rate of zymotic disease per thousand for the Bermondsey parish?

(*Chairman to Mr. Webster.*) Is it material to you to prove that, you can find it out yourself?

(*Mr. Webster.*) We have it in the evidence.

*Dr. J. Dixon.*
6 June 1883.

(*Chairman.*) That is a speculative and fishing question, is it not?

(*Mr. Webster.*) No my Lord, we have it in already, but this gentlemen says it is something different.

(*Chairman.*) You had better put the question directly.

14,604. (*Mr. Webster to the witness.*) In St. Olave's is not the death rate 4·46 per 1,000 for the 10 years from 1871 to 1880?—Are you speaking of the parish of St. Olave's, or the district, or the union?

14,605. I am speaking of the registration district?—There is no registration district, there is a union which includes several districts.

14,606. The table put in yesterday by Dr. Tripe includes St. Olave's, St. John, Horselydown, and St. James, Bermondsey, and it gives 4·46 for the average of the 10 years?—That is the union, not the parish.

14,607. Do you suggest that that is less than the average of London?—I have not suggested so.

14,608. London is 3·84 and this is 4·46; now I should like to ask you what is the rate you have got for this particular parish?—For what year?

14,609. For the average of the 10 years from zymotic disease?—4·6. This, of course, includes all kinds of zymotic disease. Last year our zymotic rate was 4·80, while the London rate was 3·49. Our rate for whooping cough was 2·03, that of London being 1·20. Our rate for measles was 1·24, that of London being 0·60. Our excess from these diseases alone exceeded our excess above the general zymotic rate for London.

14,610. Then I do not understand your statement that it is only half the average of London?—I was speaking of enteric fever, not of zymotic diseases all together.

14,611. What have you got down for fevers?—They are not separated for the 10 years, but I can give it you for the last year for fever. 1882.—Enteric fever per 1,000 population.—London, 0·25. Bermondsey, 0·10.

14,612. I asked you for it for the 10 years and you have not got it?—The tables includes the totals of all zymotic diseases.

Re-examined by Mr. Norman Bazalgette.

14,613. Bermondsey you tell us has an area of 626 acres?—It has.

14,614. It is so arranged as to present a considerable frontage to the river?—It is.

14,615. (*Dr. de Chaumont.*) Have you observed any difference in the state of health in your district in the last 10 years; is it more or less healthy than when you began your practice?—The state of health has considerably improved.

14,616. (*Sir John Coode.*) Do you attribute that improvement to any particular cause?—I attribute it to the main drainage in a very large measure, and to the filling up of the tidal ditches which formerly existed, and also to improvements in the dwellings of the poor.

The witness withdrew.

Surgeon-Major Charles William Griffith called; examined by Mr. Norman Bazalgette.

*Surg.-Major C. W. Griffith.*

14,617. You are a member of the Royal College of Surgeons of London, and a licentiate of the Royal College of Physicians of London?—Yes.

14,618. And you are also Brigade-Surgeon in charge of the Magazine at Purfleet, below the outfalls?—I am.

14,619. How long have you occupied that position?—Since November, 1880.

14,620. Do you live close to the river?—I live about 60 yards from the river.

14,621. Does your garden run down to the river?—It does.

14,622. How near is the hospital to the river?—It is about 35 yards.

14,623. What is the distance of the barracks and the residences of the various employés from the river?—The distance is about from 200 to 300 yards.

14,624. Speaking from the medical records which you have since 1876 of patients admitted to the hospital, can you tell us whether they contain any cases of disease which can be fairly attributed to the emanations from the river:—I do not think they do.

14,625. (*Chairman.*) Do you smell the sewage at all at Purfleet?—No, I do not.

14,626. Do you see it at all in the river, as it were?—The river is discoloured at times.

14,627. (*Sir John Coode.*) Do you experience any smell which you attribute to the factories?—Yes, there is a blood manure factory and a glue factory, one I believe is at Rainham, and the other I believe is on the other side of the river, upon the Erith side of the river.

14,628. (*Mr. Webster.*) Do you refer to Rainham in Kent?—No, to Rainham in Essex.

14,629. (*Sir John Coode.*) Do you mean that the smells of which you speak are never due to the river?—I have not perceived any.

14,630. Have you endeavoured to distinguish them as far as possible?—Yes, I should have done so if the river smell had been perceptible.

14,631. (*Mr. Norman Bazalgette.*) Are those smells that you smell from the factories equally prevalent whether the tide is flowing or ebbing?—It depends upon the wind, a north-west or west wind brings the smells which I originally attributed to the river.

14,632. (*Sir John Coode.*) What is the bearing of these factories from the magazine?—I should say west-north-west.

14,633. (*Mr. Norman Bazalgette.*) So that the wind you spoke of would convey the smells from the factories to the magazine?—Yes, I do not know where they are exactly.

(*Sir John Coode.*) I should have thought the factories were north-west to the magazine.

14,634. (*Mr. Norman Bazalgette.*) Referring once more to the record which you are speaking of, have you any case of typhoid fever upon record?—No, but one has recently occurred.

14,635. Is diarrhœa prevalent in the neighbourhood?—Not specially; rather the contrary, I should say.

14,636. What is the general health of the troops and the employés?—Very good.

14,637. Did I understand you to say that you have never smelt the river?—No I have not, except when the local drainage has been out of order.

14,638. And in hot weather, in summer, do you sit with your windows and doors open?—Yes, they are always open in summer weather.

14,639. (*Sir John Coode.*) All these factories would be to the west or north west from you, and therefore how a southerly would bring them does not clearly appear?—A west or north-west wind I referred to; Erith is west of Purfleet, and Rainham would be to the north of that again.

(*Sir John Coode.*) I can understand a westerly wind bringing the smell.

14,640. (*Mr. Norman Bazalgette.*) Is there much mud upon the Purfleet side of the river opposite the magazine?—No.

14,641. What is the shore there?—It is shingle and chalk stones, there is very little mud.

Cross-examined by Mr. WEBSTER.

14,642. Will you kindly tell me when you smelt these smells which you originally attributed to the river, and then attributed to the factories?—When I first went down there.

14,643. Could you give us that by the year?—It was about, I should say, early in 1881.

14,644. Have they continued since?—Yes, but they are worse since, because there is a new factory established at Rainham.

14,645. You smelt those smells early in 1881?—I did.

14,646. Now Rainham—is Rainham in Essex?—Yes, it is.

14,647. Do you know where the factories are to which you have attributed the smell?—I will tell you, as nearly as possible. The Rainham factory is situated close to the river bank opposite Rainham Station, as nearly as posible in a line with the Rainham Station.

14,648. That is to say, the Rainham station in Essex?—Yes.

14,649. Do you trace it to anything particularly; do you know the smell?—I know the smell well.

14,650. Do you know what it is the smell of?—Yes, I do.

14,651. What is it?—It is the smell either of a glue or a blood manure manufactory.

14,652. Now there is a factory at Erith, you say, where is that?—I do not know where the Erith one is situated.

14,653. (*Sir John Coode.*) Is there a factory at Erith?—Yes.

14,654. A south-west wind would bring that you?—Yes.

14,655. (*Mr. Webster.*) Would you say where you understand the factory at Erith to be, which you think you have smelt?—I do not know where it is.

14,656. You have been there since November, 1880?—I have.

14,657. That is a matter of something more than two years?—Yes, it is.

14,658. Do you know the "Cornwall" training ship off Purfleet?—Yes.

14,659. Where is that, above you?—It is below me, about 500 yards.

14,660. She is moored, if I remember rightly, upon the Essex shore?—Yes, on the Essex shore.

14,661. And a little below the outfall sewer?—Yes, it is about 350 yards from the outfall.

14,662. There has been a considerable outbreak of typhoid fever there, has there not?—It is always more or less prevalent there, I believe.

14,663. That has been the case with that ship and the boys there as long as you have known it, I understand?—There have been cases now and again, I believe, always.

14,664. And this last outbreak is a serious one, is it not?—It is not more so than others, as far as I have heard.

14,665. I am speaking of serious in itself, do you know the number attacked by it?—I do not know that.

(*Sir John Coode.*) Do you say there is an outbreak now?—Yes.*

14,666. (*Mr. Webster to the witness.*) Do you know that between 40 and 50 of the boys were attacked with typhoid fever during the last month?—No, I did not know that so many as that had been attacked. I know there have been some.

14,667. There have been several cases of typhoid fever, have there not, upon the shore at Purfleet during the last month?—There was one, that I know of.

14,668. Do you mean that you know there is only one, or that you only know of one?—I only know of one.

14,669. And scarlet fever?—Yes, there are several cases in the village now.

14,670. You were there in 1880; not in the summer of 1880, but in the summer of 1881 and 1882?—Yes.

14,671. You would agree, would you not, that from a temperature point of view and from a humidity point of view, 1881 and 1882 would be very favourable to the river in respect to not smelling, would they not?—I do not remember exactly whether they were hot summers or not.

14,672. You do not remember that either of them were hot summers?—No.

14,673. I suppose you would agree that if there is a considerable amount, or if there is more, what I will call fresh water in the river or land water, and the river is at a higher average, the river would not be so likely to smell?—It would not.

14,674. And if it did smell, it would not be so injurious to health?—I cannot answer that question.

14,675. What registration sub-district is your district in?—It is in the parish of West Thurrock. Purfleet and West Thurrock, I believe, it is called.

14,676. Do you know what Union it is in?—I could not tell you. I believe it is in the Orsett Union.

14,677. Do you know what registration district it is in?—I do not know that. I have nothing to do with that. I have nothing to do with the civil practice at all.

14,678. But you are the medical officer?—I am only medical officer for the barracks. I have nothing to do with the civil returns.

* The witness afterwards stated that his informant was wrong, there had been no case of typhoid, the cases called so were scarlet fever.

Cross-examined by Mr. BEAUMONT MORICE.

14,679. What kind of smell will you get from the factories at Erith?—It is difficult to describe the smell, but it is a very disagreeable one.

14,680. Being a medical man, can you tell us at all?—I think it is indescribable. I think having once smelt it you would remember it.

14,681. Do you know the village of Erith?—Not much, only from landing there occasionally.

14,682. (*Sir John Coode.*) Are you distinctly of opinion that the smell is not from the river?—I am quite certain as to what the smell is, I recognise it, distinctly.

14,683. (*Chairman.*) Do you ever smell it with an easterly wind?—No, I do not.

Re-examined by Mr. NORMAN BAZALGETTE.

14,684. Do you smell the smells from the factories chiefly in winter or summer?—I smell them chiefly in summer.

14,685. Now about the outbreaks of typhoid fever upon the "Cornwall," do you know anything about them, from your own knowledge?—I have occasionally visited the cases in consultation with Mr. Brett, the medical officer of the ship, and I have frequently seen cases for him in his absence.

14,686. At any rate, you have told us, that amongst the troops that are under your care, there has not been one case of typhoid fever?—There has not been one case since 1876, I think. But there is a case of typhoid fever at this moment in the quarters of one of the employés of the magazine, but he is a clerk in the employ of the London and Tilbury Railway, and was on a visit at home when he was attacked.

14,687. When he contracted the disease?—It is

*Surg.-Major C. W. Griffith.*

6 June 1883.

difficult to know when he was attacked, or when he contracted it, but he was at home when it broke out

14,688. (*Sir John Coode.*) How many men have you got at the magazine?—85 or 90.

14,689. All told?—Of the troops, but there are magazine employés in addition.

14,690. How many come under your charge?—Roughly speaking, men, women, and children, about 300.

14,691. You have been speaking of these 300 in the course of your evidence?—I have.

14,692. (*Mr. Norman Bazalgette.*) Referring once more to the outbreaks on board the "Cornwall," can you, as a doctor, attribute them to any special cause?—Do you mean whether I think they arose from the fact of the boys being on board the ship?

14,693. To what cause do you attribute the outbreak?—It is difficult to say—the boys there are continually being admitted—they are brought from the streets, and it is perfectly possible that a boy introduced may have the seeds of typhoid fever in him, and communicate them to others. I think one case, if I recollect rightly, was traced to that very cause.

14,694. (*Sir John Coode.*) Is the "Cornwall" the nearest ship to the outfalls?—It is the nearest training ship to the outfalls.

14,695. (*Chairman.*) I will ask you one question—do your men bathe at all?—They are not allowed to bathe in the river at all, because it is extremely dangerous, from the way in which the water runs into the bay, they do bathe there, but they are strictly prohibited from doing so, and, of course, they are punished if they are caught doing so, but, nevertheless, they do occasionally bathe there.

14,696. I do not know whether you are fond of bathing or swimming yourself, but is the water there such that you would not mind bathing in it yourself?—I do not think I should do that for several reasons. In the first place, the current is most desperately strong, and there are all sorts of currents, and, of course, the water is not so clean as you would wish it to be.

14,697. (*Dr. Stevenson.*) Referring again to the present outbreak on board the "Cornwall," you have been on board the ship, were you able to trace any case to importation by the boys?—I only went in consultation with the present medical officer.

14,698. (*Mr. Webster.*) Have you any knowledge of the present outbreak?—Yes, I have, but not as to the number of cases.

The witness withdrew.

Captain WILLIAM MILLER called; examined by Mr. NORMAN BAZALGETTE.

*Capt. W. Miller.*

14,699. You are captain of the "Castalia," and have been so ever since she was launched?—I have belonged to her since she has been launched.

14,700. For the last six and a half years where has she been stationed?—At Galleon's Reach and at Erith.

14,701. She has been stationed four years and a half at Erith, and for a year and eight months before she was at Galleon's Reach?—Yes, that is so.

14,702. Where is she stationed with regard to the tide?—She is stationed in the full strength of the ebb.

14,703. (*Chairman.*) Where is Galleon's Reach?—It is at the bottom of Woolwich Arsenal.

14,704. (*Mr. Norman Bazalgette.*) From on board the "Castalia," can you on the ebb see any traces of sewage in the river?—You cannot see any traces of sewage.

14,705. What can you see?—You can see refuse of all kinds floating there.

14,706. What kinds of refuse?—You see such things as grease floating down, and cabbage leaves, and things of that sort.

14,707. Do you see any excrementitious matter?—No.

14,708. (*Chairman.*) Is the paper which is used in the closets all mashed up by that time?—Yes, it is; you cannot see it.

(*Mr. Norman Bazalgette.*) Do you remember the hot summer of 1881?

(*Mr. Webster.*) You call it a hot summer, but I do not think that the statistics show that it was so.

(*Witness.*) I do.

14,709. (*Mr. Norman Bazalgette.*) Did you observe any smell from the river then?—There was a slight smell, not much.

14,710. At what period of the tide was this?—It was about the first shoot of the ebb.

14,711. Did you smell it during the year 1882?—I did not.

14,712. Taking the years 1881 and 1882, can you tell the Commission whether you have been in the habit of bathing in the river?—I have repeatedly in 1881 and 1882. I have always enjoyed myself in the river bathing; that is at the top of high water.

14,713. (*Chairman.*) That would be just before the outlet of the sewage, would it not?—I do not exactly know when they let out the sewage.

14,714. But that is so, I think, is it not?

(*Mr. Norman Bazalgette.*) I think that would be so.

(*Chairman.*) You are speaking of where you now are in Erith Reach.

(*Witness.*) The vessel is lying in Erith Reach at present.

14,715. And that is where you bathe?—Yes, inside of the vessel.

14,716. (*Sir John Coode.*) Did you bathe when the vessel was in Galleon's Reach?—I have bathed once or twice in Galleon's Reach, but not very often.

14,717. (*Chairman.*) Do I understand that you bathe in the open river?—Yes, there have been several gentlemen accompanied me bathing, and they always enjoyed themselves in the river.

14,718. (*Chairman.*) I do not see why not, the water is salt and clear at that time, is it not?—It is salt and clear at that time.

14,719. (*Mr. Norman Bazalgette.*) You have been on board the "Castalia" ever since she has been stationed there?—I have.

14,720. How many nights have you slept on board the ship?—I have slept on board, with the exception of about twelve nights altogether.

14,721. What kind of health have you enjoyed?—Excellent.

14,722. What crew does yours consist of?—Two men and a boy.

14,723. What sort of health do they enjoy?—They always enjoy excellent health.

14,724. Have you had any cases of illness on board?—None, but a boy was bad with rheumatic fever, and he was taken to the hospital in Erith and died.

14,725. Do you often smell bad smells where you are stationed?—Sometimes from the factories we do.

14,726. Do you trace those smells to any particular factory?—There is a glue factory. I do not think the smell comes much from the oil factories, but there is a glue factory where it comes from.

14,727. Which wind do you get them with?—A north-west wind; they are very bad indeed then.

14,728. Do you get those smells at any particular time of the year, or do you get them all the year round?—All the year round.

14,729. (*Sir John Coode.*) Do you get them from a south-east wind?—We cannot get them from a south-east wind.

14,730. But I want to know, do you get any smell from a south-east wind?—We get a smell from the brickworks with a south-west wind, but not from the factories.

14,731. It is a different smell altogether from what you get if the wind is north-west ?—Yes, that is so.

14,732. (*Mr. Norman Bazalgette.*) Is there a brickfield in the south-west ?—Yes, there is.

14,733. Has that a bad smell ?—It has, but it is nothing like the factory.

14,734. Have you had at times to shut your cabin door to try and keep the smells out ?—Yes, many a time.

Cross-examined by Mr. Webster.

14,735. You were in Galleon's Reach in 1881, am I right in that ?—No.

14,736. Not in 1881 ?—We came to Galleon's Reach upon the 22nd March 1877, and were removed to Erith on October the 4th, 1878.

14,737. And since October the 4th, 1878, you have been stationed at Erith ?—Yes; I have been stationed in the "Castalia" all the time.

14,738. What have you been doing there ?—I have been amusing myself partly.

14,739. The "Castalia" being laid up, do you remain there all day ?—Not all day. I go on shore occasionally, amusing myself; shooting sometimes.

14,740. I want to know this, have you bathed in Galleon's Reach ?—Yes, I have once or twice.

14,741. You were there for three or four years, why did you not bathe there more often ?—I beg your pardon, if you will look at the dates, seeing that I was there from 1877 to 1878, you will find I was not there for three or four years.

14,742. Did you bathe there ?—It did not suit me to bathe there perhaps.

14,743. But why did you not bathe in Galleon's Reach ?—Why did I not bathe this summer in Erith Reach ?

14,744. (*Chairman.*) Is it the fact that you did not bathe there because the water was not tempting; do you remember ?—Not at all; by no means; if I thought I wanted to have a swim, I should have gone in.

14,745. (*Mr. Webster.*) Do you suggest that the water in Galleon's Reach was inviting to bathe in ?—Yes, it was.

14,746. Was it just as inviting as in Erith Reach upon the top of the tide ?—No; scarcely.

14,747. Why not ?—Because there is not such a head of water comes up there upon the top of the tide.

14,748. Then the water is better in Erith Reach ? Yes; if you go round the river you will understand that.

14,749. Erith Reach is three or four miles further down than Galleon's Reach, is it not ?—Yes it is.

14,750. Now you say you remember the hot weather of 1881; how much of it was there ?—I cannot say.

14,751. Was there a week ?—I think there was more than a week.

14,752. About what month was it ?—It was June and July, I think.

14,753. The river began to smell faintly, as you have said ?—Yes, it did.

14,754. About how long after the hot weather began did the river begin to smell faintly ?—It was smelling when the hot weather was on.

14,755. What was it smelling of ?—That I cannot say.

14,756. Can you describe the smell ?—There are so many smells, I cannot pick them out.

14,757. Did you mean a smell from the water when you said the river began to smell faintly ?—Yes.

14,758. Had you ever smelt it before ?—No, I had not.

14,759. And you have never smelt it since ?—I have not.

14,760. Was there any smell in 1882 ?—No; there was no smell in 1882.

14,761. (*Chairman.*) Did it smell at all times of the tide ?—No, it smelt about the first shoot of the ebb.

14,762. That was just after your bath then ?—Yes, after my bath.

14,763 (*Mr. Webster.*) What I want to put to you is this: you do bathe when you have the fullest amount of water up ?—Yes.

14,764. Did you not know that the sewage was let out upon the beginning of the ebb ?—I did not know whether the sewage was let out upon the beginning of the ebb, or not.

(*Chairman to Mr. Webster.*) Can you not trust the Commission for this ? Captain Miller says, and with perfect truth, that just at the turn of the tide he bathes.

14,765. (*To the witness.*) I suppose you could not comfortably bathe when the tide is running strong, could you ?—I could not.

(*Chairman.*) Then the witness says that shortly after that he smells a strong smell, and we know that is about the time the sewage is let out; cannot you trust to us to know that that is the time that the sewage comes out ?

14,766. (*Mr. Webster to the witness.*) I understood you to say that you did not know exactly the time; you knew the sewage was turned out shortly after high water, or about high water ?—It is turned out about high water, or shortly after high water.

Examined by the Commission.

14,767. (*Sir John Coode.*) Do you perceive any sign in the colour of the water of the sewage being let out. Do you think you could tell, standing on board the ship, when that sewage is coming near the ship ?—I could not. I have watched for the sewage coming down most minutely, and have never noticed any sewage in the river whatever.

14,768. Have you watched it with the object of detecting it ?—Yes, I have, because there was so much said about it in Erith.

14,769. You have often watched it with that view ? —Yes, I have, and I have never been able to detect it.

14,770. About what time was it when you expected to see the sewage coming from the outfall ?—About three-quarters of an hour after the ebb came down.

14,771. (*Chairman.*) Why was the "Castalia" removed from Galleon's Reach ?—Because after the loss of the "Princess Alice," when she was lying there, it was said that we blinded the reach, that vessels could not see their way up the reach.

14,772. (*Sir John Coode.*) You mean that, the reach being narrow, the two boats combined obstructed the view; that was the reason ?—Yes.

The witness withdrew.

*Mr. E. Doggett.*

6 June 1883.

Mr. EDGAR DOGGETT called in; examined by Mr. NORMAN BAZALGETTE.

14,773. Are you an assistant accountant in the office of the Metropolitan Board of Works?—I am.

14,774. I believe you have been in the Metropolitan Board of Works for 20 years?—Yes, I have.

14,775. And for two years previously you were in the Census Office?—I was.

14,776. And during that time you had frequent experience in collecting and arranging statistics?—I had.

14,777. Did you assist Dr. Tripe in getting the tables and figures which he put in yesterday at Somerset House?—I did.

14,778. Will you state in what way you assisted him?—I attended several conferences with Dr. Tripe and the solicitor to the Board of Works, and talked over the information that was required, that is to say, the matter of the selection of the sites that would be affected by the sewage, if any sites were affected.

(*Chairman to Mr. Norman Bazalgette.*) Where is the "Cornwall"; is it above or below the outfall?

(*Mr. Norman Bazalgette.*) It is below; it is just opposite the word "Purfleet"; it is a mile or two miles below the "Castalia."

(*Mr. Webster.*) I am told it is about a mile.

14,779. (*Mr. Norman Bazalgette to the witness.*) Will you tell us what steps you took to assist Dr. Tripe in his investigation?—I attended at certain conferences at which the question of selecting the areas which would be injuriously affected by the smell of the sewage was gone into. Those areas were pointed out on the map, and I then visited the areas (Greenhithe excepted, as the registrar had put no addresses against the deaths there) with a view to ascertain by personal inspection the names of the streets and parts of streets, and the street numbers of houses that were within those areas. I then went to Somerset House, and had access to the books of the Registrar-General, and, having made out a list of the streets and parts of the streets within the various areas, I obtained a copy of the Registrar's books of deaths and took out the whole of the deaths that happened within those various areas.

(*Chairman.*) What is the object of this gentleman's evidence? He actually ascertained the statistics upon which Dr. Tripe reasoned. Is that the effect of it?

(*Mr. Norman Bazalgette.*) That is one point of it, but another is that he has visited the localities himself, and he will tell us something about the density of the population.

(*Witness.*) Having made out a list of all the deaths that occurred within those various areas, I sent copies of those lists to Dr. Tripe.

14,780. I believe you also went over the Registrar-General's register of deaths, and obtained a list of deaths occurring on board the training ships and in the infirmary at Greenwich?—I did.

14,781. And that information you also sent to Dr. Tripe?—I did. I also obtained the occupations of some persons who died within the various areas, where it was thought necessary by Dr. Tripe.

14,782. And you went to the office of the Metropolitan Asylums District Managers, and obtained the report of the various hospitals under their control?—Yes, and from them I tabulated the deaths from all diseases, except smallpox, under the head of typhus, scarlet fever, enteric fever, and other diseases.

14,783. The Commission have before them Dr. Tripe's spot maps that he brought yesterday. I believe you have been over the Erith district which is shown upon the spot map?—Yes, I have.

14,784. You walked over it with the map in your hand?—Yes, I did.

14,785. Can you tell us whether the ordnance survey is corrected up to the present?—It is not. At least my copy was not, and I was told that my copy was the latest printed.

14,786. In what respect is it incorrect?—Many rows of houses and streets are not marked upon the ordnance surveys.

14,787. I believe you produce a map which shows the ordnance map of Erith up to date?—To a certain extent it is corrected, but I am not a surveyor, and of course it is only roughly done. It was done for my own purposes.

(*Sir John Coode.*) It is corrected in what respect—as regards new buildings or additional buildings?—Yes.

14,788. (*Mr. Norman Bazalgette.*) My next question covers that. (*To the witness.*) Will you point out in what respect it differs from the published ordnance map?—There are a great many streets and rows of houses which are in existence now, and have been for many years, which are not down upon this map,—this map, the ordnance survey, having been made many years ago.

14,789. (*Sir John Coode.*) At what date, do you know, was that map published? You will find it at the bottom of the sheet?—This was surveyed in 1865. I was told at the time that this was the last published map; so that anybody looking at the map of Erith would say that there are a great many open spaces in such and such divisions which really do not exist, as they are now covered with houses more or less.

14,790. Is this evidence with reference to the questions that were asked of Dr. Tripe yesterday with regard to the open spaces?—Yes.

14,791. (*Mr. Norman Bazalgette*) Speaking generally, should you say that any part of Erith can be said to be densely populated?—No, no part of Erith can be considered to be densely populated.

14,792. Where are the houses closest?—The houses are closest in the small district, that would be at the angle of High Street, starting from the "Yacht," and going in an easterly direction up High Street, and then turning in a southerly direction as far as Colebrook Street. From Colebrook Street to the river they run one way, and then in an opposite direction from Colebrook Street, crossing the High Street, across to a point near the police station; and from there again to the "Yacht." That would comprise the district which is most closely populated. The "Yacht" is a public-house near a public-house called the "Crown," where a double dotted line runs out to low-water mark, on the map.

14,793. (*Mr. Norman Bazalgette.*) Then there is another densely populated part at the lower end of the Bexley Road, is there not?—The little district I have spoken about would include the lower end of the Bexley Road.

14,794. That part, as the map shows, is all adjacent to the river?—That part is all adjacent to the river.

(*Chairman.*) Is this evidence for the purpose of accounting for an apparently larger number of spots upon Dr. Tripe's plans?

(*Mr. Norman Bazalgette.*) No. It is to show that the district which Dr. Tripe said was singularly free from spots is, as a matter of fact, densely populated.

(*Chairman.*) It is not to explain away an apparently bad case, but to make an absolutely good one.

(*Mr. Norman Bazalgette.*) It is merely to show the density of the population.

14,795. (*To the witness.*) Now will you do the same thing with regard to Woolwich; will you just show where the most densely populated parts of Woolwich are. I believe you have been over the Woolwich area to determine this question more than once?—I have been over the Woolwich area twice, and the parts I am about to speak of I have gone all through.

14,796. Which is the most densely populated part?—The part of Woolwich which is bounded on the north by Rodney Street and upon the west by Globe Lane; it is bounded on the south by High Street, and on the east by Harden's Lane.

14,797. I daresay you can give me the dimensions of the plot which is enclosed by those boundaries?—I have measured it out by the ordnance survey, and I find it is 460 feet upon the south side and about

500 on the north, and the mean depth is about 200 feet.

14,798. That gives an area, I believe, of about 96,000 square feet?—Yes, about 96,000 square feet.

14,799. How many houses are marked upon the ordnance survey plan?—96, and there is a rather large space in Nelson Street occupied by a lecture hall.

(*Chairman to Mr. Norman Bazalgette.*) Is this hopeful? Could not you ask this gentleman in a general way whether it is not a fact that these districts are densely populated; how can we carry in our mind that there are 96 houses in any particular place?

14,800. (*Mr. Norman Bazalgette.*) If your Lordship will remember, when I was asking the witness about Erith, he said that no part of Erith could be said to be densely populated, but that the houses were closest in the riverside area. (*To the witness.*) Taking Dr. Tripe's map which was put in yesterday, could you say that the houses are closest upon the margin of the river?—Yes, they are.

14,801. Does the same thing apply to the Greenwich spot map?—Yes; the most densely populated part of the area for Greenwich is the part near the river.

14,802. I believe you have been also over the Rotherhithe district?—I have.

(*Chairman.*) Have we got to Rotherhithe again?

(*Mr. Norman Bazalgette.*) I thought you took Rotherhithe as a boundary inclusive.

(*Sir John Coode.*) We heard a good deal about Rotherhithe.

(*Chairman.*) It might be a remarkable thing as showing that the river did not poison people there; but, as you have no sewage discharged up there, I do not see what is the use of it.

14,803. (*Mr. Norman Bazalgette.*) A witness was called on the part of the Corporation who gave very elaborate evidence to show that Rotherhithe was made unhealthy on account of the river passing through it. I refer to Dr. Browning. (*To the witness.*) I will put it generally. Taking Dr. Tripe's spot map, is the district nearer to the river in Rotherhithe densely populated, or more densely populated, compared to the rest of the district?—The most densely populated part of that district is the part nearer to the river.

14,804. I gather from your answer that you do not mean immediately abutting on the river?—No, the whole of the immediate frontage to the river in Rotherhithe is occupied by wharves and public-houses, upon the other side of the street the houses are very close together indeed, especially at the western part of the area upon the map.

Cross-examined by Mr. Webster.

14,805. This plan which you have put in of Erith even now shows a considerable number of open spaces, does it not?—Yes.

14,806. You do not mean to describe Erith as a densely populated place?—I stated that it was not a densely populated place.

14,807. And with regard to the other plans to which you have referred, do you say, taking the last one, namely, Rotherhithe, that Adam Street and Albion Street are not as densely populated on the average as any other area of equal size?—I think not, because you will find that between Albion Street and Adam Street all the houses have little back gardens which are equal in size or larger than the houses themselves, and besides that there is a good broad street all round.

14,808. Now, with regard to Woolwich, I want to ask you this question. As it stands now, is not the population substantially equally distributed over the whole of the map?—No, I do not think it is.

14,809. Which do you say is the most densely populated?—In the small area which is chosen by me as being the most densely populated; I think you will find that the houses are more close there than in any other part of the area taken.

The witness withdrew.

Dr. Francis Mead Corner called; examined by Mr. Norman Bazalgette.



14,810. You are a Member of the Royal College of Surgeons of England, and a Licentiate of the Apothecaries' Society?—I am.

14,811. You are and have been, I believe, for some time past Medical Officer of Health to the south district of Poplar?—I have.

14,812. For what period have you occupied that office?—I have occupied that office since September 1877.

14,813. Does the south district comprise those portions of the district which front upon the river?—It does. I have a skeleton map here which gives the boundary of the district to which I am medical officer, it extends from Blackwall to Limehouse, the river boundary being about 6 miles.

14,814. I believe, in addition to your being medical officer, you have had a private practice in Poplar for some 25 years past?—I have.

14,815. As a general practitioner amongst all classes?—Yes.

14,816. Do your patients include those employed upon the river, and in the docks and factories which adjoin the river?—Yes, they do.

14,817. Generally, has your experience in the district during the last 25 years induced the conclusion in your mind that the presence of sewage in the river has had any injurious effect upon the health of the district?—I have had no facts at all to suggest that.

14,818. Do you find that illnesses from typhoid, diphtheria, diarrhœa, and other zymotic diseases, are more present in the district immediately adjacent to the river than in those more remote from it?—No.

14,819. Are there a number of factories by the side of the river?—There are a great many.

14,820. Do they employ a large number of hands?—I may say many thousands.

14,821. Who all live in the district?—The great majority of them live near.

14,822. Do you find that the diseases you have named are prevalent amongst them?—No, I do not.

14,823. Do you have opportunities of comparing the health of your district with that of the north district of Poplar?—Yes; every month a return is made of all cases of death, and of cases of infectious disease arising both in my district and in that on the north, that is, Bow and Bromley.

14,824. That is for that part of the Poplar district furthest from the river?—Yes.

14,825. Do you also have an opportunity of comparing the class of diseases occurring in Poplar with that occurring in the Isle of Dogs?—Yes, I have. My district is divided into two arbitrary divisions, that is to say, the district over which I am medical officer, by the route cut across the Isle of Dogs by the East and West India Docks; they cut off the Isle of Dogs from the north of my district.

14,826. The Isle of Dogs is entirely surrounded by the river, is it not?—By the river and the docks.

(*Chairman.*) The docks were originally intended to be a canal to cut short the way round the island.

14,827. (*Mr. Norman Bazalgette.*) Do you know what the resident population of the Isle of Dogs is?—It is about 16,000.

14,828. (*Mr. Webster.*) Is that south of the West India Docks?—Yes, it is south of the West India Docks.

*Dr. F. M. Corner.*

6 June 1883.

14,829. (*Mr. Norman Bazalgette.*) Speaking of these districts, do you find that zymotic disease is, in proportion to the population, more prevalent in the riverine districts than in those further removed from the river?—I should say generally not, though in the last five years we have had an epidemic of scarlet fever in the Isle of Dogs, but to my mind it was not at all connected with the condition of the river; it was traceable to a particular school, and nearly all those attacked were children in that particular board school. I do not think it had anything to do with the condition of the river.

14,830. During the years 1857 and 1858 you were resident medical officer of the Seamen's Hospital "Dreadnought," were you not?—I was.

14,831. Where was she stationed?—She was stationed a little to the Metropolitan side of Greenwich.

14,832. And whom was she occupied by at that time?—They were sailors principally.

14,833. How many patients had you on board?—From 150 to 200, in addition to the officers.

14,834. (*Chairman.*) Did you attend them?—I lived on board.

14,835. (*Mr. Norman Bazalgette.*) Do you remember the summer of 1857, before the Metropolitan outfalls were opened?—I do.

14,836. Were there great complaints of the state of the river in that year?—There were.

14,837. Did the river, at the time when it was so much complained of, have an injurious effect upon the health of the people who lived upon the "Dreadnought"?—No, we could make out no ill effects whatever on board the "Dreadnought" either in the patients or in the attendants and officers living on board.

14,838. Did that strike you at the time as being a remarkable fact?—Yes, it did, very.

14,839. (*Chairman.*) Even then it did not affect you?—Even then, we had no evidence of evil effects in the patients or officers; we had none of the effects that you would have expected.

14,840. (*Colonel Ewart.*) Was the water foul in smell?—Yes, it was unpleasant to the smell; that is to say, in rowing to and fro, you got a very unpleasant smell.

14,841. (*Mr. Norman Bazalgette.*) Did you receive a good many cases of typhoid fever, and treat them there?—Yes, we had a considerable number.

14,842. Did you find in any case of typhoid fever that came on board that the disease was communicated to others?—No, it was not; we had a considerable number of cases of typhoid fever, sometimes over a dozen, on the medical deck to which I was attached at one time; but, with one exception, during the two years I was there it did not spread to another patient.

14,843. Dr. Letheby at that period was the medical officer of health for the City of London?—He was.

14,844. Did you, at his request, report these various facts to him?—Yes, I did.

14,845. (*Mr. Webster.*) Is the report in writing?—Yes, it was a private communication. What use Dr. Letheby made of it, I do not know.

14,846. (*Mr. Norman Bazalgette.*) I may take it that, as the result of your experience at Poplar, the Metropolitan outfalls have not had an injurious effect upon the health of the inhabitants at Poplar?—Certainly not. I have no evidence of it.

14,847. (*Chairman.*) Do you yourself see any sewage at Poplar?—No, I cannot say that I do. In certain portions of the bends of the river where the tide gets in, you do get a certain amount of mud, but I have had no complaints of bad smells from those who live there; and I have been in houses overlooking the river, and I have never had occasion to notice any smells.

14,848. I suppose it would be worst at Blackwall?—It is worst at Blackwall, where the Trinity Corporation has its premises.

14,849. (*Mr. Webster.*) That is at the corner of Bow Creek?—Yes, where the River Lea has its entrance; but the wash of the steamers going up and down seems to cleanse the banks of the river to a great extent where we are.

Cross-examined by Mr. Webster.

14,850. Have you smelt it at Blackwall and Bow Creek yourself?—No, I cannot say that I have ever noticed anything objectionable from the banks of the river, or the river itself.

14,851. Neither at Blackwall or at Bow Creek?—No.

14,852. Is it your view that the condition of the river in London, in 1857 and 1858, was not injurious to health?—There is no such evidence, either from my experience or the experience of others with whom I have had the opportunity of talking. For instance, taking Dr. M'William, who was surgeon to the Customs, his experience was that the Custom House officers, who worked on the Thames did not suffer unduly.

14,853. But I want an answer to the question. Is it your opinion that the condition of the Thames in 1857 and 1858, in London, was not injurious to health; it is not a question of whether it is evident or not, but as a medical man, is it your opinion that it was injurious to health?—I should expect that it would be.

14,854. Are you aware that the death rate in London did sensibly diminish after the sewage being taken to Barking and Crossness?—Yes.

14,855. Do you not attribute that to a great extent to the sewage being taken out of the water between Chelsea and London Bridge?—I should be more disposed to attribute it to the sewage system than to removing it from the water in the Thames near London. I think it was the system.

14,856. I do not understand you?—The sewerage system has removed the sewage more rapidly from the homes of the people than before. There were a great many cesspools existing before.

(*Chairman to Mr. Webster.*) You would hardly suggest that the people at Highgate suffered from the sewage being in the Thames in 1857, would you.

(*Mr. Webster.*) I am not saying so at all.

(*Chairman.*) But the death-rate is diminished all over the metropolis.

(*Mr. Webster.*) I am referring to the evidence of previous witnesses to the effect that the condition of the river and the mud as it was in 1858 was distinctly injurious to health.

(*Chairman.*) Who said that?

(*Mr. Webster.*) Sir Joseph, then Mr. Bazalgette, and Mr. Hawksley.

(*Chairman.*) And the witness said he should have thought so.

(*Witness.*) I should have thought so undoubtedly.

14,857. (*Mr. Webster to the witness.*) You have given evidence to day that for some accidental reason or from extra precautions the bad condition of the river did not affect people upon the "Dreadnought." What I want to know is, is it your judgment as a medical man that the health of London was not improved by taking the sewage out of the river?—I believe it would be, at the same time I have no facts to support that.

Re-examined by Mr. Norman Bazalgette.



14,858. Under the system of sewerage which then prevailed, as you told us, there were a number of cesspools?—Yes.

14,859. And in addition to that all the sewers that discharged into the Thames were tide-locked?—Yes.

14,860. It is to the removal of that bad unsanitary state of things that you attribute the decrease of disease, rather than to the taking of the sewage out of the river in London?—Yes, I believe that is the more important of the two factors, the removal of the sewage quickly from the houses and the streets has been of more importance to health than diverting it from the river at London.

14,861. (*Chairman.*) But I understood you to say, you should have expected, taking this very case of the "Dreadnought," that it would have been a bad position for the vessel to be in, that it would have been better for the "Dreadnought" and the patients in it if the water that ran by it had been pure?—Yes.

14,862. But you could not trace any disease to the foul condition of the water?—I could not at that time.

14,683. I suppose one way in which it might affect health might be this, that if the smell was so offensive as to cause nausea that would be detrimental to health?—Yes, but it was found that when we got from 15 to 20 feet above the level of the Thames, nothing offensive was noticed. It was curious that after getting a certain distance up the stage ladder, nothing offensive was noticed, but at the surface of the water or a few feet above it, it was distinctly nasty.

14,864. (*Sir John Coode.*) That would be at the time when the air was quiescent, would it be the same when a breeze was blowing?—I should expect the offensive smell would be experienced. At a higher level when the air was still.

14,865. Then the condition of the offensiveness would be one depending on the state of the wind?—Yes. I presume the free dilution by the air of the gases given off would have something to do with it, either by dilution or destruction of the offensive gases.

14,866. You think there was a line of demarcation about 15 feet above the water level?—Yes.

14,867. Did you notice that more than once?—Yes, it was a matter of common observation among those on board.

14,868. Did you suggest it to anybody?—No. I think it was common observation.

14,869. You mean that it was so strongly marked, that it struck different people as a fact?—Yes.

The witness withdrew.

(*Chairman to Mr. Norman Bazalgette.*) May I take the opportunity of asking you what more witnesses you contemplate calling?

(*Mr. Norman Bazalgette.*) We shall have, I should say, three or four chemical witnesses.

(*Chairman.*) Could not you examine them *en bloc* and call them in together?

(*Mr. Norman Bazalgette.*) Though we shall probably have to examine the principal chemical witnesses at length, we can take the others comparatively shortly.

(*Chairman.*) You might have the others in the room, and then after you have examined your principal witness, you might say to them, "Do you agree "with that evidence, or do you desire to add to or "qualify it in any way?"

(*Mr. Norman Bazalgette.*) To a certain extent we can do that, but scarcely to the whole extent.

(*Chairman.*) You will have three or four chemical witnesses?

(*Mr. Norman Bazalgette.*) Yes.

(*Chairman.*) And some microscopical witnesses, I presume.

(*Mr. Norman Bazalgette.*) Yes.

(*Chairman.*) And I think you have one more engineer to call, have you not?

(*Mr. Norman Bazalgette.*) I think there are two more, my Lord.

(*Chairman.*) Is that all?

(*Mr. Norman Bazalgette.*) I hardly like to take the responsibility of saying that that will be the case on behalf of the Metropolitan Board of Works.

(*Chairman.*) But as at present advised?

(*Mr. Norman Bazalgette.*) There may be a few more.

(*Chairman.*) It is all important for us to get through this matter upon this side of the holidays.

(*Mr. Norman Bazalgette.*) If your Lordship would say that above a certain point of the river you would consider that health was not affected, that would shorten the matter.

(*Chairman.*) I should not like to give an interlocutory decision of that sort.

*Mr. Norman Bazalgette* stated that, having no more witnesses to call to-day, he would proceed with the reading of the Erith agreed documents. (*The same was proceeded with. See Appendix A. J.*)

In the course of the reading, the following discussion occurred.

(*Chairman.*) If I understand rightly, Erith is shown to be a very healthy place; nobody says that any disease is traced to the sewage of the outfalls in the Thames, that is to say, no specific diseases.

(*Mr. Norman Bazalgette.*) That is so.

(*Chairman.*) You are showing that from other causes, Erith ought not to be a healthy place.

(*Mr. Norman Bazalgette.*) I think the object of the evidence rather is to show that what many witnesses have described as being the smell from the river, really was the smell of the factories.

(*Chairman.*) That might be your object, and is reasonable enough.

(*Mr. Lumley Smith.*) But the witnesses on both sides agree that the smells are distinct, that the smell of the river is quite distinct from the smell of the factories.

(*Chairman.*) What Mr. Bazalgette wants to show is, that there are such smells, and that is admitted, except that Mr. Webster asked whether there were any bad smelling manufactories at Erith.

(*Mr. Webster.*) That was to endeavour to get at the source of the smell the witness said he smelt at Erith, and his answer to me was that he did not know where it came from, so that I could not follow it up.

(*Mr. Lumley Smith.*) My learned friend has rather relied upon these documents as showing that the complaints are all of the factories and not of the river. Now there are several paragraphs which seem to show that at the time Dr. Jessett was of opinion that the river was in a very bad state. In the 5th paragraph of that Report, at page 7, he says, "I would again "draw attention to the fact that undoubtedly a large "quantity of sewage sent out from Crossness and "Barking is carried by the current on the river on to "our shores. Strenuous efforts should be made to "prevent this, but at present the outfalls are pro-"tected by the Public Health Act."

(*Mr. Norman Bazalgette.*) My learned friend relies upon these sort of passages, and I rely upon these passages in the Report taken in connexion with them to show the extreme healthiness of the district.

(*Mr. Lumley Smith.*) Dr. Jessett was asked for these reports by the Metropolitan Board of Works, and they have been produced at their request.

(*The reading was resumed.*)

(*Sir John Coode.*) That paragraph as to comparison in the Report of January 28th, 1881, has to my mind the effect of showing the desirability of carrying the comparison over a longer period, say seven, or eight, or ten years.

6 June 1883.

(*Mr. Norman Bazalgette.*) If you look at the date of the first report, you will see it begins practically in 1879, and winds up, I think, in 1882 or 1883.

(*Sir John Coode.*) Here is a comparison of the year 1880 with the year 1879, and the effect of the comparison upon my mind is to show the desirability of comparing a much longer period with another long period, because to compare one single year with another single year may easily be fallacious.

(*Mr. Norman Bazalgette.*) I am reading the paragraph to show what steps have been taken by the local authority to obviate the nuisance, but if I may anticipate by referring to a passage to show the state of things which exists at present, if you will turn to the end of the printed matter, that will show the state of things at present; it is at the bottom of page 19.

(*The reading was resumed and concluded.*)

Adjourned to Tuesday next at half-past 12 o'clock.

# THIRTY-NINTH DAY.

## Tuesday, 12th June 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.

FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst. C.E.

WILLIAM POLE, Esq., F.R.S., *Secretary.*

Mr. HENRY LAW re-called; cross-examined by Mr. WEBSTER.

*Mr. H. Law.*

12 June 1883

14,870. (*Mr. Webster.*) I propose to take the few questions which I have to put in the order of the number to save your Lordship trouble in referring to them; but I must first refer to this. (*To the witness.*) I think you stated that you were acquainted with all the evidence given before the Commission?—Yes.

14,871. And you are of course acquainted with Sir Joseph Bazalgette's evidence?—Yes. I did not hear the whole of it, but I have a general acquaintance with it.

14,872. Did you hear it stated that the rain at Greenwich and Kew did not correspond?—I know he made that statement, but I did not hear it.

14,873. Were the tables from which Sir Joseph Bazalgette spoke prepared by you?—No, they were not.

14,874. Were they prepared under your superintendence?—No.

14,875. Or in your office?—No, they were not.

14,876. Have you considered the question of the rain corresponding at Kew and at Greenwich?—I have not looked into it recently, but I know from the former observations which were made by the Referees, and of course, I know it from general meteorological observations, that frequently when it rains at one place it does not at another, and especially that the heavier the rain the more partial.

(*Chairman to Mr. Webster.*) Would you mind telling me what is the discrepancy?

(*Mr. Webster.*) Sir Joseph Bazalgette said accidentally, because I am sure he would not misrepresent anything, that the rain at Kew and Greenwich did not correspond.

(*Chairman.*) Do you mean it did not correspond in point of volume, or quantity, or time?

14,877. (*Mr. Webster.*) That it did not rain upon the days at Kew when it rained at Greenwich; in fact, there was not a single day upon which it corresponded with the tables put in by Mr. Symons. (*To the witness.*) Now, I will ask you, have or have you not examined the tables, not speaking of general observation, but examined the tables with the view to form any opinion as to the coincidence of rain upon the same days at Greenwich and at Kew?—No, I have not examined the tables put in by Mr. Symons with that view

14,878. Or the tables put in by the Metropolitan Board of Works?—No.

14,879. Do you know that Mr. Symons' tables only showed the days upon which the rain exceeded 1 inch?—Yes, I do.

14,880. But I may take it that you have not gone into the question yourself?—No, I have not.

14,881. I will call your attention, if you please, to question No. 13,645, in which you refer to Mr. Baldwin Latham's general statement that the population of London and the sewage requirements of London have outgrown the drainage system; do I understand you as differing from that?—Yes.

14,882. You say it has not?—I do.

14,883. To what do you attribute the necessity for the large increase of storm outfalls being provided, say, during the last 10 years; do you know, one way or the other, that they have provided during the last 10 years a largely increased number of storm outfalls?—Yes; they are now at the present time providing increased storm overflows to take the rain from districts which, in consequence of new streets and roads being laid out, have had their rainfall brought into the sewers.

14,884. Will you forgive me if I ask you to answer the questions first, and then add anything by way of explanation. Now would you tell the Commission, as I understand you have the information, what number of storm overflows have been provided during the last 10 years?—I cannot do that.

14,885. (*Chairman.*) Can you tell the capacity?—I cannot do that.

14,886. (*Mr. Webster.*) Can you tell us the places at all where they are being made?—One is being made at Vauxhall Bridge, to relieve the Effra sewer, one is being made at Wapping, to relieve the Hackney Valley sewer, running out at London Wharf. Those two I happen to have been engaged upon, and, therefore, I know them.

14,887. Are there any others which you know?—I know there is another being made to relieve one of the tributaries of the Ravensbourne.

14,888. Where is that to come out; do you know?—I cannot give you the details of that.

14,889. But which side of the river is the Ravensbourne?—Upon the south side, at Deptford.

14,890. Has not there been a storm overflow provided coming down from Brixton and running into the Thames at Battersea?—I think that is the one I referred to as relieving the Effra.

14,891. When was that opened?—I cannot give you that. Sir Joseph Bazalgette will be able to tell you that better than I can.

14,892. And the Fleet Valley?—Yes, the Fleet has been relieved also.

14,893. How recently has that been done?—I cannot give you the exact date, but I think that would be about five years ago.

14,894. I would ask somebody on the part of the Board of Works to be good enough to put in a tabulated shape the storm overflows which have been provided in the last 10 years, with their capacity and place, and generally the districts which they are supposed to relieve?—No doubt that can be done.

14,895. Is there any occasion for the increased storm overflows in the old districts, except what I may call the increase of sewage?—It is the increase of rainfall, not the increase of sewage.

14,896. As between what periods?—Between the period when the sewers were constructed and the present time.

14,897. But I understand you to say, as your own engineering judgment upon it, that it is due to the increase of rainfall being different from what was contemplated?—I did not say that. I said the increase of rainfall, which is occasioned by the altered conditions of the present time, from what they were when the sewers were constructed.

14,898. You can easily get over me if you put it in those general words; but I ask you, do you say there is a larger rainfall now going on than that which was contemplated when the sewers were designed?—I do not say the rainfall itself is larger, but I say that in consequence of the increase in the surfaces which contribute the rain to the sewers, the rain which now comes down is larger in amount than that which was provided for.

14,899. (*Sir John Coode.*) I understand that a larger proportion of the rain which does fall has to be carried away through the sewers; is that what you mean?—Yes. For instance, in the Hackney district, formerly it either sunk into the ground or was taken off by the ditches or evaporated, but now that new districts are laid out and large surfaces are paved, the same result does not follow, but a larger proportion has to be carried away by the sewers.

14,900. (*Mr. Webster.*) You say it is partly due to the fact that more of the rain that falls is conducted into the sewers?—Yes.

14,901. That is from there being more paved surfaces and roads and houses?—Yes.

14,902. (*Chairman.*) Is not Sir Joseph Bazalgette the right person to ask this question, saying to him, you have given so much greater capacity of storm outfall, why did you do it. The witness is not the proper person to put it to. (*To the witness.*) I do not know whether you can give the answer?—I know it as a general fact.

14,903. But you do not know why it was done?—I do not know the details of the several cases, or the details of the necessities of the several cases.

(*Mr. Webster.*) Sir Joseph Bazalgette gave no evidence in chief which would have led me to cross-examine upon it, because Sir Joseph Bazalgette expressed no criticism upon Mr. Baldwin Latham's statement that in his judgment the present population of London had overgrown the drainage system.

(*Chairman.*) We can solve that difficulty by asking Sir Joseph Bazalgette to attend, and I will ask him the question, because you are asking Mr. Law for a speculative answer upon what may have been the motive, when you have a witness of unimpeachable integrity who can tell you what absolutely was the motive.

(*Mr. Webster.*) I have not the least wish to ask a single question which the Commission think unnecessary. I am quite willing to postpone any branch of the case; but finding in a statement of Mr. Law's that he differed from Mr, Baldwin Latham upon this point I felt justified in cross-examining Mr. Law as to his grounds.

(*Chairman.*) Did Mr. Baldwin Latham attribute these additional storm outfalls to the capacity for sewage not being adequate?

(*Mr. Webster.*) He never referred to it in that way.

(*Chairman.*) Then Mr. Law could never have differed from him in that way.

(*Mr. Webster.*) Your Lordship is taking one answer of Mr. Law's this morning, and taking it as Mr. Law's evidence in chief. Mr. Law's answer to me this morning is, "I do not agree with Mr. Baldwin Latham "that the population has outgrown the sewage "system." Now I ask him, if you do not agree with Mr. Baldwin Latham that the population has outgrown the sewage system, how do you account for the increase of storm outfalls.

(*Chairman.*) I think Mr. Law might tell you, "I do not know, and I do not care"; whereas that question could be answered in a moment by Sir Joseph Bazalgette.

*The Committee consulted together.*

(*Mr. Webster.*) I simply wished to intimate to the Commission that I did not accept and swallow whole a great many of the conclusions that Mr. Law has come to. I think I can show that Mr. Law has fallen into some errors. I do not in the least wish to follow up any of those errors beyond just indicating them.

(*Chairman.*) We think you ought to do so.

14,904. (*Mr. Webster to the witness.*) You say: True, there has been an increase of population, and that that has let more rain water into the sewers, and that has necessitated more storm outfalls; that is what you meant?—Yes.

14,905. That would, of course, bring with it an increased burden of sewage as well?—Yes, there would be an increase in the sewage.

14,906. Therefore, whenever the population goes on or houses go on increasing, leading to more rain being brought in, you have approximately a proportionate increase in the sewage as well?—Not necessarily; you cannot say that they bear the same proportion.

14,907. I do not say so. I said approximately proportionate?—It is a question how far the approximation might hold.

14,908. Would you now look at your diagram, No. 22; it is what you call the heavily-dotted district; will you tell me what is the district which you indicate as having that large increase of population in colour?—Even the colours do not show the increase of population.

14,909. Will you tell me which are the districts in which you say the large number of houses are growing up?—I have made no statement as to that.

14,910. You said just now that you attributed the necessity for storm outfalls to more rain being taken into the sewers from the houses which were being built?—No, I did not. I said it was the extension of paved roads, and so on, and the altered conditions of surface which have occasioned more rain coming down into the sewers.

14,911. Which is the district in which th increase is taking place?—The Hackney Valley is one, and the Valley of the Effra is another, and the Quaggy, which runs into the Ravensbourne, is another.

14,912. Does that plan show us which of the districts had sewers provided for a rainfall of an eighth of an inch in the day, and which for a quarter of an inch?—No.

14,913. Is there any plan which does, which I can compare with that?—I am not sure; it is in some of Sir Joseph Bazalgette's earlier reports, but I have not it with me.

14,914. I asked for the information in another shape, and I think it appears so upon the notes?—I am sure that Sir Joseph Bazalgette can give you the respective areas upon which he formerly took an eighth of an inch and a quarter of an inch.

14,915. Are you aware that the increase of population and building has taken place to a far larger extent

*Mr. H. Law.*

12 June 1883.

in the districts for which provision was made only for an eighth of an inch?—I do not think so.

14,916. Do you know one way or the other?—I think that a far larger increase of population has taken place in Battersea.

14,917. Any facts which you have, which you can speak to of your own knowledge as contravening what I put to you upon the north side of the river, I shall be glad to hear?—I cannot tell you the districts which have the larger provision upon the north side.

14,918. Will you tell me the districts which had that provision for an eighth of an inch?—I cannot.

14,919. Now will you turn to question 13,650. I observe that in that you give your total population at 2,596,054, in the table following that question; is that correct?—Yes.

14,920. Of course it has increased since 1881?—Yes; I gave the increase as 2 per cent.

14,921. For what population were the sewers designed?—I do not know.

14,922. I will put the figures to you?—But you must not take it from me whether they are right or wrong, because I have not the means of checking them.

14,923. But I will just put them to you, and you can correct me?—In Table No. 1 you have it divided; it is allotted there amongst the three sewers.

14,924. Now I will put it to you to see whether this is or is not accurate, that the contemplated population of the High Level sewer was 290,500, as against 256,329 which is what you have got for the High Level. For the Middle Level the contemplated population was 1,041,300 as against 1,209,081; and for the Lower Level 1,022,100 as against 1,130,644. Now assuming those figures to be correct, I will give you the results directly. Assuming that I am correct in suggesting to you that the population estimated for at the time of the sewage system for the northern district was 2,353,900, there would be an excess in the year 1881 upon the north side of upwards of 242,154 in 1881 only?—Yes, there is that difference between those figures.

14,925. Now, assuming, if you please, that the increase of population over the estimated or contemplated numbers did take place in the year 1881, do you still adhere to your answer that the drainage system is sufficient?—Yes, I adhere to it, and I have proved it by the figures I have put in to be amply sufficient.

14,926. Do I understand you to say distinctly that you had in your mind, when you prepared this diagram, the population contemplated by the original drainage system?—No, that formed no part of the inquiry. My inquiry was how far the drainage system was adequate to meet the wants of the existing population.

14,927. Then you have not considered what it was originally intended to meet. Now I will just take the south side, if you please. I wish to put the figures before the Commission. The High Level is 412,800 and the Low Level 681,800, and that makes 1,094,600 as against 1,284,048; those figures, you have said, you also did not have in your mind?—I would like to make one observation upon that. I do not know what you are reading those figures from; I do not know, for instance, the date of that report or estimate, and how far in the preparation of the matured plans deviations and alterations may have been made; because it is very possible that the allotments of the areas of the respective High, Middle, and Low Level sewers, which were originally contemplated, have been to a certain extent changed in the carrying out of the work; that must be borne in mind.

14,928. I am not dealing in the least with possibilities or probabilities, but I am asking this. Assuming those figures of population to have been estimated as having to be provided for by the sewers, as designed, your evidence is that the sewers were sufficient for a much larger population. Are you able to tell me if those figures are correct, in what the difference between the capacity of the sewers at one time and the other lies; is it in the different mode of calculation of the capacity of the sewers then from now, or what?—I should say certainly not; but you are asking me things quite out of my knowledge. But what I wish to say is this, that you have before you the whole of my calculations, the formula by means of which the discharging capacity of the sewer has been taken, is the one always used by engineers, and the only proposition I have put before the Commission is that the sewers are more than sufficient for the present population, that is quite independent from what may have been estimated for.

14,929. (*Chairman.*) There appears to have been an increase of population on the north side by 10 per cent.?—Yes, about 10 per cent.

14,930. I think Sir Joseph Bazalgette told us that he had provided for an increase of population, but he says the sewers will carry off double the amount of sewage that they now have to carry off when there is no rain; that is so, is it not?—They will carry much more than double.

(*Chairman to Mr. Webster.*) But I speak within compass; that is so, is it not?

(*Mr. Webster.*) I am following your Lordship.

(*Chairman.*) And that is true.

(*Mr. Webster.*) If it is true, a great many of my questions become unnecessary, but I think it is not true.

(*Chairman.*) Sir Joseph Bazalgette told the Commission, that he had had a piece of good fortune which he had not calculated upon. He calculated that the great bulk of the sewage would be running over the whole space at the same time, whereas he found that owing to the distance it had to travel, it did not come in that way. The question is, therefore, not what Sir Joseph Bazalgette calculated at the moment when he designed the sewers, but the question is what is their capacity now.

(*Mr. Webster.*) I respectfully submit that I do not accept Mr. Law's conclusions. I know your Lordship has put a question which has enabled Mr. Law to repeat what he believes to be true.

(*Chairman.*) I always give credit to counsel, and I should unquestionably do so to you, that they have some point to make when they persist after I have pointed out a difficulty. If you could show that the sewers are not anything like adequate to carry off the whole of the sewage when they are charged with rain, that would only show that the upper part of the river got more sewage into it than it ought to get; and upon that I should say that there is not a shadow of complaint about the upper part of the river.

(*Mr. Webster.*) With submission, that is not my point at all.

(*Chairman.*) Then you had better go on. I trust completely to counsel that they will not unnecessarily occupy time.

14,931. (*Mr. Webster.*) I am much obliged to your Lordship. I will not put a single question which is merely argumentative, and I will not put a question except for the purpose of indicating the view we take. (*To the witness.*) Now I notice at Question 13,652 that you have said you have adopted gaugings which were taken by Mr. John Taylor for the Referees to whom the Metropolitan Drainage Scheme was referred?—I did say so.

14,932. Do you allege that those gaugings are accurate?—I have every reason to believe that they are.

14,933. Do you say you have every reason to believe that they are?—Certainly.

14,934. Are you not aware that Sir Joseph Bazalgette, Mr. Bidder, and Mr. Hawksley, have repeatedly pointed out that the gaugings were wholly inaccurate?—I was not aware of that.

14,935. Did not you say that at the time you adopted them?—No.

14,936. Have you read the report of the 6th of April, 1858?—I have read it, but not very recently.

14,937. I will not trouble you to read it through now; are you not aware that Sir Joseph Bazalgette,

Mr. Hawksley, and Mr. Bidder, declined to work upon those gaugings?—No, I am not.

14,938. Are you not aware that Sir Joseph Bazalgette, then Mr. Bazalgette, refused to work upon those gaugings?—No, I am not aware of it.

14,939. You said "I have adopted the gaugings "which were taken by Mr. John Taylor for the "Referees to whom the Metropolitan Main Drainage "Scheme was referred by the First Commissioner of "Works previous to the construction of those "works; because those experiments extended over "some three or four months, and were taken with "very great exactness." Upon whose authority was this?

14,940. (*Chairman.*) What were these gaugings?—The plan for the Metropolitan drainage was referred under the Act to the Commissioner of Works who appointed a Commission, and that Commission deputed Mr. John Taylor to take elaborate gaugings of the metropolitan sewers for the purpose of determining the quantities which would have to be dealt with; but I would explain that I have made a very partial use of those gaugings. I have not used those gaugings to determine the quantity of the sewage, but only the rate of its distribution, the relative quantities coming down at different hours. The quantity has been determined upon the same basis that Mr. Baldwin Latham adopted, namely, the 5 cubic feet in 24 hours, and these gaugings were used simply to determine the rate of distribution.

14,941. (*Mr. Webster.*) I will read your own answer, "In order to determine the hours"?—Certainly, not the "quantity" but the "hours."

14,942. Will you kindly listen to me, "In order to "determine the hour at which the maximum flow "from each branch sewer will come down into the "intercepting sewer (by which I mean the Board's "sewer), I have adopted the gaugings which were "taken by Mr. John Taylor." My question to you is, do not you know that the accuracy of these gaugings was disavowed distinctly by Mr. Bazalgette?—No, I do not; but I should like to see the comments, because those comments would probably only refer to the mode of gauging and determining the quantity, and would probably not affect the relative quantities coming down at different times, that is the only purpose for which I used them.

14,943. I will refer you to page 48 of the Report of April 6th, 1858, on Metropolitan Drainage "Un-"questionably the most important results to be "obtained from gaugings is not that sought by the "Referees, but the determination of the amount of water "passing through the sewers as the produce of rainfall. "Dry weather gaugings for determining the amount of "ordinary sewage may be taken at any time, and on "only a few occasions, as they may be assumed to "afford, from a comparatively small number of "observations, a tolerably accurate result; the mode "in which the Government Referees took their "gaugings." Then the report describes the mode in which the Referees took their gaugings?—I have used only the dry weather gaugings.

14,944. "We have earnestly endeavoured to turn the "elaborate gaugings of the Referees to use for the "accomplishment of this end, and have expended "much time in efforts to reconcile discrepancies, to "eliminate errors, and to interpolate facts otherwise "derived, but we have not succeeded in this attempt "as we had desired. The Referees appear indeed to "have had objects in view altogether different from "those which we conceive to be most essential in an "inquiry of this kind. Having ascertained, to their "own satisfaction, the amount of the ordinary sewage, "they proceed to determine not the amount of rain-"flow which ought to be excluded from the river by "the sewers of interception, but the amount of "dilution necessary to render effective the only pos-"sible system of working the very peculiar outfall "channels." I will not read the rest of it, but I will ask you this, can you tell me any single report or inquiry since these gaugings in which they have been used by Sir Joseph Bazalgette or anybody else until you used them?—I really cannot; but what you have read there does not impugn the use that I made of them the least in the world, it impugns the use the Referees have made of them as regards the rainfall. I have simply used them for the purpose of determining the relative rates and not the quantities.

14,945. Can you give me the table of gaugings you have used?—It is Appendix 3, page 78, of the Report upon Metropolitan Main Drainage, 1857.

14,946. Will you just tell me how I shall know which gaugings you have used?—I have used the gaugings, as, in fact, it is stated at the head of Diagram No. 23, for the Northumberland Street sewer, the Essex Street sewer, and the Norfolk Street sewer.

14,947. Have you left out the Savoy Street sewer?—Yes, I have.

14,948. I put it to you thus—are you not aware that these are the very gaugings in which errors from 10 to 33 per cent. were pointed out by Sir Joseph Bazalgette at pages 51, 52, and 53. I have indicated enough for the Commission to follow what I mean?—My reply to that is exactly what it was before,—if I had made any use whatever of these gaugings to determine the quantities of rainfall mixed with sewage that were flowing, those errors would have applied; but I have simply used them for the purpose of determining the hourly rate at which the dry weather sewage comes down.

14,949. But that is the quantity flowing, is it not?—No, if you were to deduct the per-centages from those various amounts, it would remain identical.

14,950. But the hourly rate at which the sewage come down does give the quantity passing, does it not?—Not at all,—because one sewer may bring down double the quantity of the other, and they may both flow at the same relative rates; one sewer may discharge 100 times that of the other, and yet the rates be the same.

14,951. If you have given you the capacity of the sewer and the passage of the sewage, you know what is coming down?—Yes, of course, coming down you do; but I say I have used them simply for the purpose of determining the relative quantities, and not the absolute quantities.

14,952. Now, I will refer you to question 13,653. You say the maximum flow out of the Northern Outfall sewer is 15,000 cubic feet per minute, do you say that as a matter of fact?—I do.

14,953. Is it all pumped, or does part of it flow by gravitation?—The High and the Middle Level sewers flow by gravitation.

14,954. Then the answer is that the Low Level sewer is the only one that is pumped, and the others flow by gravitation?—Yes.

14,955. Do not they pump at Abbey Mills as much as 15,000 cubic feet a minute alone?—At the present time, do you mean?

14,956. I will ask you another question, what does your diagram No. 24 purport to show, because you have represented, as I understand your answer, that the maximum flow in the outfall sewer is 15,000 cubic feet a minute?—Yes, in dry weather without rain.

14,957. Of sewage?—Yes.

14,958. Now, I put it to you,—do you represent it as never exceeding that?—Of course not; when rain makes it larger, it exceeds it.

14,959. Then I do not understand what you mean by your answer to question 13,653, when you say, "The portion of the diagram coloured red shows at "each hour how much of that discharging capacity "would really be occupied in carrying away the "sewage at that particular hour; and therefore your "Lordship will see that the maximum flow in the "outfall sewer upon the northern side is at half-past "two, when it amounts to about 15,000 cubic feet." If you will tell me exactly what you mean by that, I shall be obliged?—I mean to say absolutely that that is the fact; and not only that, but that this is an over estimate by 50 per cent., because at the present

*Mr. H. Law.*

12 June 1883.

moment we have only two sewers working instead of three, and the height of the sewage in the two sewers is about what I take it at in the three at the present instant.

14,960. What I understand you to say is that the sewage alone will not exceed 15,000 cubic feet a minute?—Yes, that is purely an estimate, taking 5 cubic feet to an individual, and that the gaugings which I myself took the other day, being down there upon other business, showed that that was an over estimate.

14,961. Now, will you tell me what is the quantity by gravitation as compared with that which is pumped. I am told that 22 per cent. flows by gravitation to 78 per cent. pumped; if that is right, then I can pass on?—No, it is not that.

(*Sir John Coode.*) Is it not all pumped at Abbey Mills?

(*Mr. Webster.*) No, I understand the Middle and the High Level sewers run in by gravitation.

(*Witness.*) That is so; only the Low Level sewer, the 10 feet 3 sewer, is pumped.

14,962. (*Mr. Webster.*) I am told that Sir Joseph Bazalgette stated in the Mud Inquiry, that 22 per cent. of the sewage discharged at Barking goes by gravitation, and 78 per cent. is pumped?—But that would include the whole that there is, whereas I am only alluding to the dry weather flow.

14,963. But I am giving the percentage?—They simply pump the sewage out of the Low Level sewer.

14,964. (*Chairman.*) But the percentages must vary very much, because, as I understand, you said the High Level sewer had a vastly greater capacity compared to its work than the other sewers had?—Yes; the High Level is only filled to one-seventh while the Low Level is filled to one-half of its capacity. (*To Mr. Webster.*) I can answer your question; the High Level maximum flow is 1800 cubic feet a minute, the Middle Level maximum flow is 7,788 cubic feet per minute, and the Low Level maximum flow is 6,570 cubic feet, making together 15,070; they will not quite add up, because those are the respective maxima at different hours.

14,965. (*Mr. Webster.*) But my question was, what percentage of the actual discharge is pumped?—I will give it you; out of the 15,000 there is about 6,000 pumped.

14,966. That is got by adding the maxima quantities together?—Yes.

14,967. Now will you go to Question 13,658; you have added it up against yourself by 10,000 acres, it should be 65,000 acres instead of 75,000 acres; that is at question 13,658?—That is so.

14,968. Do you agree with the view expressed by Sir Joseph Bazalgette and others that there ought to be from each acre provision for a cubic foot and a half of sewage and rainfall?—I do not understand the question, it would depend upon the density of the population.

14,969. That there ought to be provision made, never mind whether it comes from one person or a thousand, for a cubic foot and a half per minute per acre of discharge?—But it must depend entirely upon where you put the acre; whether it is in the centre of a town or in the suburbs makes all the difference, you cannot lay down a general rule of that kind.

14,970. I only want to get you to answer the question?—You cannot make a general rule of that kind when you have a city more or less densely peopled in various parts.

14,971. But you do not agree, taking the 102 square miles and the 65,000 statute acres, that you can say what should be the quantity actually coming off per minute per acre?—That is the result of an arithmetical calculation, I cannot tell you whether or not the right proportion of sewage to an acre over the whole of London would come to $1\frac{1}{4}$ or $1\frac{1}{2}$ cubic feet.

14,972. I am not putting to you the sewage; I distinctly made it clear to you, if you followed me, sewage and rainfall yield in liquid per statute acre per minute; do you agree that a cubic foot and a half or a cubic foot is the right quantity to provide for?—Under what conditions; it depends entirely upon the conditions of the district you are dealing with.

14,973. The district of the Metropolitan area?—It may come out upon the average to that. I cannot say how that may be.

14,974. Have you, or not, formed any judgment as to what is the proper quantity as the governing principle?—I stated the principle I have taken here, viz., that of taking the whole of the rainfall as coming down where there are more than 80 persons to the acre, and then proportioning it to the number of persons to the acre.

14,975. Have you worked it out to the proportion per acre per minute in cubic feet?—No, I have not, and I do not know how it would work out.

14,976. Now I will refer you to your answer to question 13,661, you have taken the velocity at 180 feet per minute in the sewer?—No, that is not the velocity exactly through the sewer, it is the velocity of the rain in reaching the intercepting sewer, it may be through the sewer, or it may be through the gutters.

14,977. Would you enable me to check the formula through which you get at your 180 feet?—It is not determined by a formula at all.

14,978. How do you arrive at it?—It is purely as an estimate.

14,979. I presume, in arriving at the figure of 180 feet, you must have had some data to work upon?—Not at all.

14,980. (*Chairman.*) Then how did you arrive at the conclusion?—I know more or less what the velocity in the sewers generally is.

14,981. (*Mr. Webster.*) Then let us have it more or less?—180 feet per minute is rather a quick velocity; therefore I assumed what would be rather upon the safe side. So I took what was rather a high velocity, notwithstanding all the bends and turns of the sewer, and 180 feet per minute would be a good velocity in a well constructed sewer.

14,982. Then this is from some general opinion that you have that 180 feet is a high velocity?—Certainly.

14,983. Were the sewers actually gauged in 1865 as to the rapidity of the flow through them?—I am not aware of that.

14,984. Are you not aware that the sewers were actually gauged for velocity and quantity, and samples of the sewage taken from time to time and submitted to Professor Way?—No. I have been informed by Sir Joseph Bazalgette that he has made every search in the archives of the Metropolitan Board of Works, and that they know nothing whatever of these gaugings.

14,985. I will not make any concealment about it, because I am instructed that your figures are wrong, and here are the books (*producing some books of gaugings*). Have you had any actual gaugings of the rapidity or velocity of the flow in the sewers?—Not that I am aware of.

14,986. You have not worked upon any actual gaugings?—No, I have not.

14,987. Those books appear to have been inspected by your people in 1865?—I am informed by Sir Joseph Bazalgette that they never had a person in their employ of the name of Walker.

14,988. But I know nothing about a person named Walker. I have not said anything about it?—But these books are signed by a man named Walker. Mr. Baldwin Latham wrote to inform Sir Joseph Bazalgette that he had certain books of gaugings in his possession which were signed by a person of the name of Walker, and Sir Joseph Bazalgette caused every enquiry to be made at the Board of Works. No record of any such gaugings can be found, and they know no person of the name of Walker in authority in their employment.

(*Sir John Coode.*) What do you say those gaugings are?

(*Mr Webster.*) They are samples of sewage taken from time to time and sent to Professor Way for the purpose of making analyses, and those are not sent in by Mr. Baldwin Latham, but by Professor Way.

(*Witness.*) My belief is that those samples were taken by the Essex Reclamation Company, who were at the time engaged in promoting a Bill in Parliament. They were contemplating taking the sewage from these sewers down to Essex; but all I can say is that Sir Joseph Bazalgette has informed me that the Metropolitan Board of Works know nothing about them.

14,989. (*Mr. Webster.*) Your diagram in which these figures are used is only taken for 10 hours, why is that?—Because after that time the flow remains constant.

14,990. After what time does it remain constant?—Diagram 25 is to show the increase in the quantity of rain discharged from the sewers at successive periods in consequence of its not arriving from the distant parts so rapidly as from the nearest parts, but after 10 hours it runs as a constant quantity at the rate I have given here.

14,991. This calculation is based on the assumption that the whole of the sewers are adequate to carry off a quarter of an inch of rain in 24 hours, is it not?—No. This is to test whether they are or not. It is not assumed that they are; this is to test it.

14,992. I am afraid I have not followed you. Do you state that all the sewers are sufficient to carry off a quarter of an inch of rain?—I state that they are sufficient and much more than sufficient; that when they are carrying off that quantity with the maximum sewage they have a surplus capacity of 5,452 cubic feet per minute.

14,993. (*Chairman.*) And if they are not carrying it off, we have an overflow in the upper part of the river?—Yes, when the rain exceeds that surplus, then the sewers overflow.

14,994. (*Mr. Webster.*) What quantity is presumed to have fallen over London in this period?—A quarter of an inch over the whole of London.

14,995. Is that spread over the whole of the 24 hours?—Yes; I explained the effect of the vacant space which there was in the various sewers as compensating for sudden showers.

14,996. Now, if you please, will you go to question No. 13,678, where, in answer to Sir John Coode, and to question No. 13,679, where, in answer to Professor Williamson, you were calling attention to Dr. Frankland's evidence, and you said, "I may further call "your attention to this fact that I have gone a little "carefully into this matter of rain, because you have "also a report which Dr. Frankland put in, in which "Dr. Frankland assumes that of the whole quantity "of rain which falls upon the whole of London, in-"cluding the River Thames and the canals, however "slight the shower, four-fifths falls into the sewers, "and upon that very elaborate tables have been put "in to show the quantity of detritus which is brought "by the sewer;" and then Professor Williamson asked you this question, "Does Dr. Frankland say "that there is always that proportion, or that that is "the average proportion?" and your answer was, "He says in this table 'The rain is calculated as "'falling upon 122 square miles;' the absolute area "is only 102 square miles, and that of course contains "an enormous quantity of vacant land, parks and "squares, and places from which the rain cannot find "its way to the sewers. 'And 20 per cent. is allowed "'for evaporation, which is probably much in excess "'of the truth'; he assumes that the whole of the rest "falls into the sewers;" where does the rain go off the vacant lands and parks?—Into the soil, the greater part of it.

14,997. The whole of it, do you mean?—I did not say the whole of it. I said the greater part of it.

14,998. Do you mean to say that the quantity getting into the sewer is inappreciable?—It is very much reduced.

14,999. Do you mean that it is inappreciable?—I do not say so.

15,000. Do you represent to the Commission that the water falling upon the vacant lands, parks, and squares may be thrown out of consideration altogether?—I have never said so.

15,001. Then what do you mean by this statement: "that of course contains an enormous quantity of "vacant land, parks and squares, and places from "which the rain cannot find its way to the sewers"?—Because there is a very large proportion indeed of the parks and squares, the rain from which cannot find its way into the sewers; there are certain parts, such as the gravel walks, which are drained, and from which it does run into the sewers; but the greater proportion of the parks are grass and beds, from which it would not run into the sewers.

15,002. What proportion of rain falling upon parks and squares does fall into the sewers?—I have taken it in proportion to population.

15,003. That is not an answer to the question?—It is a very rational answer. Where the population is over 80 people to the acre, I have assumed the whole going in. Where the population is over 40 to the acre, I have assumed half going in, because the population is the measure of the space in regard to the roads and roofs of houses from which it will fall into the sewers.

15,004. Now, dealing with another question upon this subject of rainfall, you were asked by the Chairman at question No. 13,685, "Have we no direct "evidence from observation of the number of times "the storm overflows have been seen to be in action?" and your answer was, "Yes, Sir Joseph Bazalgette "has given that to you; but you must bear this in "mind, those observations could only be made at those "stations where, from there being pumping or other operations going on, the Board have men to observe. "Now, at question No. 7828, Mr. Baldwin Latham is "asked, 'Taking that district, how often would the "'sewers be incapable upon the south side?' to which "he replied, 'Upon the average, every time rain "'occurred the sewers must overflow in the case of "'London';" and in the next question his Lordship says, "I do not understand that 'upon the average "'every time,'" and you replied, "That is his answer. "Then he is asked, 'Whenever it rained?' to which "he replied, 'Whenever it rained at some point or "'other they must overflow.'" Do you mean to say that whenever it rained the sewer would overflow?—Those are Mr. Baldwin Latham's words which I quoted.

15,005. Now I will ask you, are you not aware that that referred to rain which was over $\frac{1}{100}$th of an inch an hour?—No.

15,006. Do you suggest that Mr. Baldwin Latham's evidence referred to whenever it rained, independent of the quantity?—I heard him say so; it is so reported in the notes; there is no qualification about it. If you make a qualification now, we shall understand it.

15,007. Then you go on to deal with the balance of available space remaining in the sewers. You say, "The high level sewer when the maximum flow is "taking place is only one-seventh filled." What do you make the discharge capacity of the high level sewer?—The total discharge capacity of the high level sewer is 16,620 cubic feet per minute.

15,008. We have always been told that the high level sewer discharged 11,000, and the middle level sewer 11,000?—These are the discharging capacities.

15,009. I am afraid you are putting before me some figures which I do not understand. What is this 16,620?—It is arrived at by our ordinary formula.

15,010. But Sir Joseph Bazalgette has given it over and over again that the discharge of the three sewers would be 33,000?—That may be the sewers taken at an upper point; but the lower point of the sewers would be beyond that quantity.

(*Professor Williamson.*) Would there not be a difference between the "discharge" and the "dis-

*Mr. H. Law.*

12 June 1883.

charging capacity"; because the one evidence goes upon the one, and the other upon the other?

15,011. (*Mr. Webster.*) No doubt you are right upon that, but we have proceeded upon the fact that from Abbey Mills to Barking there are three 9-feet sewers which take out 11,000 feet each?—But you were not asking me that, you were asking me the discharge of the high level sewer.

15,012. But I will ask you again, what is the discharging power of the three sewers before they are united?—The high level sewer and the middle level sewer, before being united, are 12 feet in width and 9 feet 6 inches in height; the sewer is in the form of a tunnel, an invert, two vertical walls, and a semi-circle.

15,013. I think the Commission have not had these figures before. Will you tell me what you say is the discharging capacity of the high level sewer?—It is 16,620 cubic feet per minute.

15,014. And what is the discharging capacity of the middle level sewer?—Also 16,620 cubic feet per minute.

15,015. And of the low level?—14,524 cubic feet per minute; calculated by the ordinary formula which engineers use.

15,016. Then the discharging capacity of those three sewers at Abbey Mills altogether is 47,764 cubic feet?—Yes, at their outfall, certainly.

15,017. And what is the discharging capacity of the three from Abbey Mills to Barking?—34,764 cubic feet per minute.

15,018. I do not at present understand what is the good of sewers which will convey 47,000 cubic feet a minute running into others which for a long length of miles would only convey 34,000 cubic feet?—You have never laid out a system of drainage.

(*Chairman.*) I think I can tell you how it is. The average discharge of that which receives the contents of the three sewers will be more regular than the average discharge of each of the three sewers separately.

(*Mr. Webster.*) No doubt your lordship can give a reason, but I respectfully submit that it is one thing to be wise after the event and it is another thing to deal with this as the rate of actual discharge.

(*Chairman.*) But what we are trying is, not whether Sir Joseph Bazalgette was wise before, but whether the sewers are sufficient now.

15,019. (*Mr. Webster.*) I am not trying Sir Joseph Bazalgette the least in the world; but what I am wanting to do is to show that the statement that the high level sewer is only one-seventh filled is not in accordance with the facts. (*To the witness.*) For what length will it discharge this 47,000 feet?—I cannot tell you exactly. I think it is for a quarter of a mile.

15,020. Are there any inlet sewers into it within that quarter of a mile?—Yes, of course.

15,021. I do not think it follows as a matter of course?—The high level and the low level sewers are sewers of interception and do receive at every point accessions of sewage. After they are united at Abbey Mills they cease to receive anything more, and become sewers of discharge.

15,022. But my question is whether any sewers run in after they pass the pumping station?—Certainly not.

(*Mr. Webster.*) I know that your lordship will naturally think I am asking about things which have been proved over and over again, and which I ought to remember; but it has been proved over and over again, in the evidence, that the high level sewer is 9 feet by 9, whereas the witness says it is 9 feet six by 12 feet. Now I asked Sir Joseph Bazalgette for the sizes, and he gave me distinctly what I have quoted to your lordship; but this is completely new, and therefore it is not my fault that I did not understand the quantity put by the witness. I find it stated in a former report "Between the "junction and the pumping station at Abbey Mills it "will consist of two parallel culverts each 9 feet in "height by 9 feet in width, and eastward of the "pumping station it will consist of three parallel "culverts each 9 feet in height by 9 feet in width."

(*Witness.*) I can explain that. The forms of the high and the low level sewers are shown upon Diagram No. 33, they are 12 feet in width and 9 feet 6 in height, the height being governed by conditions.

15,023. (*Mr. Webster.*) Is that all the way through?—No, at the lower end of the two sewers. Then they become united,——

15,024. But never mind about their being united?—That is what we are upon.

15,025. No, it is not. What distance back does the larger cross section go upon the high level?—I cannot give you the figure now. Those are then united into the two sewers I have mentioned. There are two of those sewers of 9 feet by 9 feet as far as Abbey Mills, and when they get to Abbey Mills there are three sewers of the same dimensions.

(*Mr. Norman Bazalgette.*) I see that Sir Joseph Bazalgette was asked at question 12,761, "Then the "high level, is that a 9 feet sewer?"; and his answer is, "That is 12 feet."

(*Mr. Webster.*) Let it be put upon a diagram which will show us the distance up of that 12 feet.

(*Witness.*) The diameter varies all the way up, it gradually increases in size.

(*Mr. Webster.*) I was astonished to find that the size of the high level sewer was put at 9 feet 6 by 12 feet, because some calculations which were given to me showed that the quantity of sewage in the sewer was largely in excess of the one-seventh; but when I was told the sewer was of the dimensions of 9 feet 6 by 12 feet, I saw that the calculation would not apply, and then I asked the witness if he was correct in the areas he had given me of the sewers, but I did not understand that at the lower end the sewer went out into a bell mouth or a larger size. I thought it was the same down to the point of junction of the three, my instructions were different.

(*Chairman.*) What would it matter whether it was a seventh or a fifth, in one case the sewer would have seven times the requisite capacity, and in the other it would have five times, and what would the difference be as regards this matter.

(*Mr. Webster.*) We do not consider that Mr. Law's statements are accurate.

(*Chairman.*) It does not matter if he is ever so inaccurate in a matter which is indifferent.

15,026. (*Mr. Webster to the Witness.*) Now, I want to understand your reasoning upon question 13,703,—do I understand you to say that the fact that people sleep out of London decreases the sewage?—Certainly.

15,027. It does?—It does.

15,028. Have you made any calculation to that effect?—No, I have not.

15,029. What do you mean by your answer to Sir John Coode. Sir John Coode's question was, "What we want to arrive at is this; although the "number sleeping within this particular district may "be affected, how far is the sewage affected?"; and you replied, "I do not suggest for a moment a "diminution of sewage, although I feel confident "there is one"?—I have not taken it into account, but I am confident that it is so, for the reason I stated in answer to the previous question, that people use the closets and take their baths, and so on, where they sleep and live, and not in the city.

15,030. Is it this,—that the sewage does not come into the metropolitan drainage at all, but goes to some different place?—In some cases it comes into a different place. Take, for example, a man who lives at Windsor, his sewage does not come in at all. In other cases it comes in at a different hour, take, for example, a man at Hampstead, his sewage comes in at a different hour.

15,031. Do you think that the number of people who have gone to live outside the metropolitan area is sufficiently large to make it a matter of consideration?—It is so; there are 8,000 acres, or a ninth

of the whole area, upon which the population is diminishing.

15,032. But you are not applying your mind to my question; have you any figures to tell us what the result of this sleeping out is?—I have not taken any estimate of it, nor taken any credit for it.

15,033. Now, in answer to question No. 13,720, and the following, you say a great deal as to the important facts which you said had been wholly lost sight of, and that is about these springs bubbling up from underneath the bed of the Thames. Was it from your own observations about these swallow holes that you had been speaking of the water coming into the Thames?—Some of them are my own.

15,034. Where are they?—In the Mickleham Valley.

15,035. Those are the Dorking ones?—Yes, and also the Barnet ones; those are my own observations.

15,036. And the Canterbury ones, too, of which you spoke?—No, those are not mine, those are Mr. Prestwich's.

15,037. Do you represent that the Canterbury one comes up into the Thames?—No, I do not represent anything of the sort.

15,038. I think you did, and I will read your answer. I will first ask you, with regard to the Dorking ones, do you represent those as going into the Thames?—Yes, certainly.

15,039. Underground?—Yes, feeding the chalk, and then coming out into the bed of the river.

15,040. Do not you know that they all appear again at Leatherhead?—No, I know they do not.

15,041. Of your own knowledge you say they do not?—I know they do not.

15,042. They do not appear again at Leatherhead and go into the Mole?—No, certainly not.

15,043. (*Chairman to Mr. Webster.*) I understand the effect of Mr. Law's evidence to be this: He said the rainfall shows a certain quantity of water. Making allowance of so much for soakage and so much for evaporation, and calculating the outfall of the streams, there is a balance left; that balance must have gone into the earth therefore and must reappear somewhere, because otherwise the earth would have become saturated to such an extent—in fact it could not hold all that has fallen since the creation. Then he says some of that must appear in the Thames and some go to other rivers. (*To the witness.*) Is that your argument?—Yes.

(*Chairman.*) I do not think the witness undertook to give the definite per-centage of the subaqueous or subterraneous water, but he says there is some.

(*Mr. Webster.*) As your Lordship has given what is the right view of the witness's evidence in chief, I would venture to suggest what is the contrary view.

15,044. (*Chairman.*) But I would like to put this to the witness. (*To the witness.*) Are you aware that there are wells in London which go down now 300 feet deep before they get to water, and that there is a necessity for going deeper and deeper still?—Yes.

15,045. How do you reconcile that with your theory?—That fact is owing to the large exhaustion that takes place in their neighbourhood by the many wells that there are in London and the time it takes for the water to travel to them. I have given your Lordship facts showing what the level of the water is, and that it takes time to travel and is exhausted upon the way.

(*Mr. Webster.*) In order that your Lordship may follow it, I wish to say that I do not agree with the statement which your Lordship put of Mr. Law's evidence, that it is based upon calculation as to actual rainfall. I say, if you look at the figures of the mileage and the quantity falling there, you cannot make that allowance, and I shall hope to show that Mr. Law is erroneous; that there is not that lost water which has to disappear underground.

(*Chairman.*) Do you say that there is not so much falls as he represents?

(*Mr. Webster.*) There is as much water falls, but it is not lost.

(*Chairman.*) You suggest that it comes down into the rivers.

(*Mr. Webster.*) That it comes down into the rivers and over Teddington Weir. Then I want to point out this, that Mr. Law did distinctly state that in his judgment the water absorbed by the Dorking and Canterbury swallow-holes reappeared in the Thames.

(*Witness.*) I never said anything of the sort. I gave the Commission no particulars of the swallow holes; in fact, I only referred to the papers where they might find a description of them as illustrating the extent to which the water might be absorbed in different places. I never said a word about the Canterbury ones coming out into the Thames.

15,046. (*Mr. Webster.*) I think I had better read to you the Answers to Questions 13,752 to 13,760. You were asked "The amount of rain which is absorbed "by these surfaces may be gathered from the fact "that there are 3,794 square miles of chalk exposed "which drain into the Thames basin. This is "according to Mr. Prestwich, who is looked upon as "the best authority upon that subject. If you take the "lower tertiaries, the chalk and the upper green sand, "all of which are pervious and admit the rain, we "have upwards of 4,000 square miles of country "which is absorbing a large proportion of the water "which falls upon it. (*Chairman.*) The upper and "the lower Thames valley?—Yes, altogether. Now I "would wish to point out this. In many parts, where "either the gault or the London clay meet the chalk, "the rivers which had been formed upon less pervious "strata disappear, being absorbed by the chalk. The "Mole is so called because of the swallow-holes which "exist between Dorking and Leatherhead. At Can-"terbury a very large number of swallow-holes exist; "at Farnham there are a very large number; at "Newbury, at Hungerford, and in the valley of the "Lea between Hatfield and Barnet, there are a series "of streams or rivers which have no outlet whatever, "but disappear, and are the feeders of the Amwell "Spring, which is in the neighbourhood. I have "coloured upon the ordnance the streams as they "exist. They have no outfall into any river at all, "and could not have been gauged by Mr. Baldwin "Latham. (*Q.*) Do you find these streams come to "an end as it were. (*A.*) Yes; at South Mimms "and at Mimms they have no other outlet than being "swallowed up in the ground. They are called "'swallow-holes' or 'swilly-holes,' and there is a very "large extent indeed of them in the River Mole. "There are some of them near Canterbury 50 feet in "diameter." And then at the bottom of the page you were asked "Your theory I understand is this, "there is the water and it must get away, otherwise "that which fell upon the land would be visible. "(*A.*) It must get away, and we find that the level "all round the margin of the river is at the mean "level of the water. (*Q.*) May not some of it get "to the sea," and you said, "an enormous quantity of "it gets to the sea."—Yes, but that is not saying that all of it goes to the rivers.

15,047. You state there that you know that 3,794 square miles of chalk drain into the Thames basin, is that your own figure or Mr. Prestwich's?—Mr. Prestwich's.

15,048. Is your 4,000 square miles the same figure, I presume it is?—Of course it is not, because one gives you the chalk and the other includes the green sand and the tertiaries, the lower tertiaries which are also pervious.

15,049. Now the 3,794 is a different figure from the 4,000, is it?—Yes, the 4,000 is the addition of Mr. Prestwich's figures.

15,050. Is the 4,000 then a figure also taken from Mr. Prestwich?—It is a rough addition of those figures.

15,051. Do not you know that the 3,794 includes the areas of the Orwell, the Stour, the Colne, the Blackwater, the Cam at Cambridge, the Little Ouse, which do not go to feed the Thames at all?—I will show the exact area which they do feed.

*Mr. H. Law.*
12 June 1883.

15,052. (*Chairman.*) That is not an answer to the question?—They do not include those areas.

15,053. (*Mr. Webster.*) Do not you know that the 3,794 quoted by Mr. Prestwich includes the areas of those rivers which do not affect the Thames at all?—No, some parts of the area which he gives do run across the ridge into other valleys, but the basin is limited by the gault. The basin is formed by the gault and the surface rivers are not those which conduct the water away in the chalk.

15,054. (*Mr Webster.*) I am putting a plain and simple question to you. Do not you know that the 3,794, which you quoted from Mr. Prestwich in support of your theory, includes an area or large areas which do not go to the Thames at all?—It is not my theory; Mr. Prestwich states that they do, it is his conviction of what comes into the Thames basin.

15,055. I will ask you to read it to me directly, if you say that is so; but first I will ask you, have you consulted Mr. Prestwich before you gave this evidence.

15,056. (*Sir John Coode.*) In Mr. Law's answer to Question 13,752, he says there are 3,794 square miles of chalk exposed which drain into the Thames valley?—I should wish to put the word "basin" instead of "valley" that is the only alteration, because the term "valley" may apply to superficial undulations, whereas the term "basin" will apply to the underground reservoir with which we have to deal.

15,057. (*Mr. Webster.*) Have you consulted Mr. Prestwich's book since you gave your evidence in chief?—Not at all.

15,058. Have you got the book here?—I have it.

15,059. Will you let me see it?

(*The witness handed the book to the learned counsel.*)

(*Witness.*) The basin is formed by the gault, and I have only gone to the same line as Mr. Prestwich has done.

15,060. Now I will ask you to show me any passage which goes to show that the 3,794 square miles are draining into the Thames valley?—I do not know whether I could pick out the place where it is succinctly put.

15,061. I am told you have picked out some streams which do not drain into the Thames valley.

(*Chairman.*) Making what difference?

(*Mr. Webster.*) I am told to the extent of 1,600 out of 3,794 square miles. (*To the witness.*) If you refer to page 59 you will find his reference to the 3,794.

(*Chairman.*) No one can blame you for going into this, because Mr. Law has put down everything he could in favour of those who called him, and therefore you have a right to efface, if you can, any of his figures; but, after all, the question is, does the river stink?

(*Mr. Webster.*) But your Lordship will bear in mind the difficulty in which we are. We have had a number of eminent witnesses called, and this suggestion of the underground water bubbling up has not been put to any of them, and yet Mr. Law comes and starts the theory that there is an extraordinary dilution of the sewage in the lower part of the Thames by the water of the underground springs.

(*Chairman.*) But after all, if you like to call Mr. Baldwin Latham, or any other geologist, to say that there are no bubbling up springs, so be it.

(*Mr. Webster.*) That is not quite the point; it is stated that the water does bubble up. Now, your Lordship knows, and we know, that the swallow-holes can be traced or found again, without, of course, pretending to say that some of the water does not go in that way.

(*Chairman.*) That would diminish the probability of their being a nuisance; but, after all, the question is if there is one. I have now given the reason why it is comparatively unimportant, and, of course, can only leave it to you.

15,062. (*Mr. Webster to the witness.*) Now, have you found any statement in Mr. Prestwich's book to show that the 3,794 square miles drain into the Thames basin, as you have stated?—The whole argument of Mr. Prestwich's book is that there is water which finds its way into the Thames basin, and those are the figures which he gives. The very title of his book is "A Geological Inquiry respecting the Water Bearing "Strata of the country around London."

15,063. (*Sir John Coode.*) Do you mean into the watershed of the Thames?—No, I mean the basin formed by the gault.

(*Sir John Coode.*) Without this explanation, I, for one, certainly should have understood this as applying to the watershed valley of the Thames, because it is very important, if there is this great difference which Mr. Webster points to, to have it cleared up.

(*Witness.*) I have shown upon this map, which I have put in, the gault which forms the basin of the Thames.

15,064. (*Chairman.*) Let me see if I understand you. Supposing the surface of the ground were hard, were covered with iron, or anything you like, you have comprehended an area larger than that from which the water would fall into the Thames, as the other side suggest?—Yes.

15,065. But because you say that outside such an area as I describe there are impermeable walls or barriers of gault, therefore you had the right to take something more than the surface, because when the water which falls upon the other side of the watershed gets down some depth it will come into contact with this gault, and will be driven in an opposite direction?—Yes. The section I put in quite illustrates my meaning, that is, that the chalk being so pervious, the water penetrates to a lower surface, which is inclining, perhaps, in another direction from the chalk, and does not flow as the surface of the chalk would lead you to expect.

15,066. (*Mr. Webster.*) You quote 3,794 miles of chalk exposed which drain into the Thames basin; that 3,794 is quoted from Mr. Prestwich, is it not?—Yes, he is the authority for the surface area.

15,067. Will you kindly refer to page 59 of Mr. Prestwich's book, and I will read this to you. The 3,794 square miles which is quoted by you in support of his theory is taken from Mr. Prestwich's book, and this is the passage. "Taking the whole of the chalk "district surrounding the tertiary tracts of Kent and "Surrey, along with that portion in Hampshire and "Wilts which lies north of a line drawn from Alton "to Devizes—of Berkshire, Oxfordshire, Bucking-"hamshire, Hertfordshire, Essex, Bedfordshire, Cam-"bridgeshire, and of Suffolk, as far north as a line "drawn from Newmarket to Woodbridge,— it forms "an area of about 3,794 square miles"?—The reasoning in this book is that that is what is supplying the basin of London for the purpose of determining how far that strata would be suitable for the purpose of supplying London with water.

15,068. I think you are unintentionally misrepresenting the intention of Mr. Prestwich's book. Do you represent, for the purpose of your argument which you have been laying before the Commission, that the land going as far north as a line drawn from Newmarket to Woodbridge has anything to do with the question at all?—Yes. I say the water in the Thames basin does not depend entirely upon the inclination of the upper surface but upon the inclination of the lower surface, the gault which confines the water. It penetrates perpendicularly through the chalk till it meets with the gault, supposing there is no exit, or until it meets with the stream of water in the chalk. But I said that an enormous quantity of this chalk water went into the sea and not all of it into the river.

15,069. (*Sir John Coode.*) Can you give me the upper edge of the gault, because that seems to be the determining area. You say the water permeates through the chalk until it meets with the gault, so that the area of the upper edge of the gault is the determining area?—It is 7,891 square miles.

15,070. (*Mr. Webster.*) Where do you find that?—That is at page 98 of Mr. Prestwich's book.

15,071. But I think you have included the lower green sand?—The lower green sand should come out.

15,072. (*Sir John Coode.*) And the area of the gault itself?—That would depend upon which way the gault fell. All that fell towards the Thames basin would come into the Thames.

15,073. You are obviously wrong in including the 7,891?—That is so; it should be about 7,000. I only looked at it casually.

15,074. (*Mr. Webster.*) I observe that your answer to question 13,738 assumes that the geological conditions of the upper Thames valley are the same as of the lower?—Yes.

15,075. Do you say that they are in fact?—No, but it would require a very large examination to tell which way they should go.

15,076. I am not saying whether it tells in your favour or against you, but I ask you, have you any facts upon which you can justify your assumption that they are the same?—No, certainly not. As I say, this was merely to show that there was only half the rain allotted to the Thames below Teddington that came above. That could not be so, because there are no disturbing elements which make that difference, and it would be in face of the fact that we know that the water comes into the Thames, because we can see it in many places; but I have not gone into the question of the way in which these geological conditions would affect the matter.

15,077. Now do you know yourself, from your examination of geological books, how much of the water absorbed by the swallow-holes reappears upon a lower level of the same stream, or upon a level adjacent to that?—No, nor do the geologists who have written upon the subject.

15,078. From your own observation have you any illustration of swallow-holes where the water absolutely disappears and cannot be traced at all?—Yes; those in the Mole cannot be traced.

15,079. Do you say that there is no connexion between the disappearance and the reappearance at Leatherhead?—Yes, I say the quantities which reappear are not at all equal to the quantities which disappear.

15,080. Will you tell me upon what quantities you base that statement of yours?—Upon no quantities at all.

15,081. Now the Stour swallows reappear in the Stour, do they not?—I do not say that they do, but I state that a large quantity of the water which has been absorbed by the chalk does reappear in the bed of the Stour.

15,082. You may say it now. I do not see it in your evidence-in-chief?—It is so as a fact, and I so stated in answer to Question 13,756.

15,083. Now in your answer to Question 13,766, you have called attention to the differences between Mr. Mansergh's and Mr. Baldwin Latham's figures. Do you know that Mr. Mansergh took Sir Joseph Bazalgette's figures, and that Mr. Baldwin Latham made an independent calculation of his own. Did you know that when you occupied the time of the Commission?—I know nothing about it beyond that they differ.

15,084. And you did not take the trouble to ascertain that Mr. Baldwin Latham had made his own calculation of the actual water supply from the water companies' supplies, and that Mr. Mansergh had taken Sir Joseph Bazalgette's figures, and that that was the discrepancy between them?—But where has Sir Joseph Bazalgette given those figures?

15,085. But will you answer the question; did you know that?—How could I know it?

15,086. I merely point out the discrepancy. Professor Unwin has taken them differently again. He has taken 26,900,000?—Yes.

15,087. I will explain it all. Now will you look at Question 13,805, where you say, "Now if we take "the mean of the sea water at Brighton, at Penzance, "and other places, and in the Atlantic, as given by "Dr. Frankland in his Table No. 3, we get at 1,900, "which is nearly identical with Professor Way's "mean; and curiously enough in the mid-Atlantic "Dr. Frankland gives only 1,800." Will you tell me where you took that from?—I took that from Dr. Frankland's own tables.

15,088. Will you show me where he gives his mid-Atlantic water as 1,800. I am told that the lowest mid-Atlantic figure of Dr. Frankland for chlorine is 1,987?

(*Chairman.*) Does it matter what it is in the middle of the Atlantic?

(*Mr. Webster.*) It does not matter a bit, except that we have a theory built up upon a number of these tables, and I was told that the effect of Mr. Law's evidence was such that I ought to meet it.

(*Chairman.*) But suppose this passage were struck out, should we be any the less deficient in information to enable us to come to a conclusion in this matter.

(*Mr. Webster.*) I do not wish to pursue it.

15,089. (*Chairman, to the witness.*) If Dr. Frankland said 1,800, do you consider it a mistake, or that he is right?—I have no reason to suppose it is a mistake; he has given it in his Table No. 3 in grains per gallon, and I have reduced it to proportional parts; that sample was taken in January 1882.

(*Mr. Webster.*) I am told by Dr. Frankland himself that the lowest he has taken for mid-Atlantic water is 1,987.

15,090. (*Chairman, to the witness.*) These are your figures that I see upon the table?—If you divide the grains per gallon by 7, and move the decimal one place, that will give you the proportional parts to the hundred thousand, and that is what I have done.

(*Mr. Webster.*) I am told that that is a quotation from Dr. Frankland's table in the 6th Report of the Rivers Pollution Commission, page 132, in which it is distinctly put down at 1,987.

(*Witness.*) All I can say is that I remember Dr. Frankland being cross-examined upon that very figure; and this mid-Atlantic sample is taken in January 1882, whereas this 6th Report was printed in 1874, therefore it is impossible for that table to be a quotation from this Report: the date shows when the sample was taken, and a sample taken in January 1882 could not be put in a table in a Report that was printed in 1874.

(*Chairman.*) It seems to me manifest that what Dr. Frankland said about the middle of the Atlantic is of no consequence, whether it is a mistake or not; but in addition to that it relates to this chlorine, which does not affect us in any way except as far as relates to the upper part of the river. I think we are all agreed that that is a matter which is not really brought before us by the evidence.

(*Sir John Coode, to Mr. Webster.*) Would it materially affect your view of the question if we took the quantity of chlorine as somewhere between 1,950 and 2,000?

(*Mr. Webster.*) Not at all.

(*Sir John Coode.*) Anything beyond that is splitting hairs.

15,091. (*Mr. Webster.*) That is quite our view. (*To the witness.*) Now you were asked at the beginning of you evidence, on the second day of your examination, at No. 13,847, "I believe first of all you "wish to add something or to say something about "the observation you made yesterday with respect to "the capacity of the outfall sewers," and your answer was, "I wish to say that we have since ascertained "the quantity of rain which fell last Saturday I find "that between 9 in the morning and a quarter after "12 in the day, $\frac{17}{100}$ths of an inch of rain fell, and "between half-past 4 and 6, $\frac{15}{100}$ths, making together "$\frac{1}{3}$ of an inch in $9\frac{1}{2}$ hours, and that although only "two out of the three sewers were at work, no over-"flow occurred at any part of the system"; is that of your own knowledge?—No, that fact was given to me by Sir Joseph Bazalgette.

*Mr. H. Law.*

12 June 1885.

15,092. Now I must put it to you pointedly. Are you aware now that the Blackfriars sewer was overflowing the whole day?—No.

15,093. Would you kindly make a note of that, in order that inquiry may be made, because I am sure you would state what is accurate.

(*Chairman.*) I think you have a perfect right to say that he does not know it of his own knowledge, and that Sir Joseph Bazalgette ought to be called to prove it.

(*Witness.*) It will be of course better for Sir Joseph Bazalgette to give you that.

15,094. (*Mr. Webster.*) You have made a distinct statement that no overflow occurred at any part of the system?—I could not know it of my own knowledge.

15,095. Now see, in answer to Question, 13,849 it is stated that it is absurd to suppose that the city calculation can be right, because there would be 12 per cent. of sea water at St. Paul's Pier. Now do you not know from the actual reports before Parliament that the Lambeth Waterworks Company always took in their water upon the ebb?—Very likely.

15,096. But I call your attention to this; you say it "is almost an incredible thing. Up to a few years "back, the Lambeth Waterworks took almost the "whole of their supply from a point close to Waterloo "Bridge, from a point very little above the point "where it was alleged that the water was liable to "have 12 per cent. of sea water in it"?—They took it in as far as they could upon the ebb, but they were not able always to do so.

15,097. One word about your own knowledge of the matter. In the first place do you know that they always, as far as they possibly could, did take in at the ebb?—Yes, they did do so.

15,098. It could not be 12 per cent., you say?—Or anything approaching it.

15,099. But you did know at the time that they took it in as far as they could upon the ebb?—Yes, as far as they could.

15,100. What knowledge have you of your own or from Statistics that they did not always take it upon the ebb?—I can only refer, ——.

15,101. Refer to anything you like, what facts have you got, either statistics or statements in any Report, to show that they ever have taken it in except upon the ebb?—I can refer to the Water Reports upon the subject which I must do, and I cannot do that at the present moment.

15,102. But you told us just now that they did as a matter of practice take it in upon the ebb, and not upon the high water as your quoted answer assumed?—Yes, as far as they could.

15,103. Now one other thing which is perhaps quite as important, when you say, "or anything ap- "proaching 12 per cent. of sea water," what do you mean by that?—That anything approaching 12 per cent. of sea water would not be such as could be drank.

15,104. Did you mean one per cent.?—No, one per cent. might be drinkable.

15,105. Two per cent.?—Indeed I could not tell you; if I were to mix it, and then taste it, I could tell you perhaps, but I could not do so offhand.

15,106. What parts per 100,000 of chlorine would 12 per cent. of sea water represent?—I cannot tell you, but it is not only the chlorine; the worst of all is the sulphate of soda which gives the bitter taste, that is what would be most readily detected and would render it most nauseous, not the mere salt.

15,107. I want to get from you what proportion of sea water could be ascertained if mixed with drinking water. I want you to pledge your scientific opinion?—That I cannot tell you.

15,108. But you have told us that this city evidence cannot be believed, because that company took their supply upon the flood, and not upon the ebb, whereas I put it to you that they took their supply upon the ebb, and I put it also that this quantity of sea water could not be detected; if you think this quantity could be detected I want to know what could not?—I would say that 12 per cent. would be such a quantity that could not be drunk, but I could not go down to a point where it will not be nauseous.

15,109. Then your idea is that this water was delivered straight away to the customers without being mixed with anything else?—That the water was not mixed with other water.

15,110. But do you mean to say it was delivered away without being mixed with water which did not come in at high water?—No, I do not say that.

15,111. Then upon what ground do you say it could not be true, because the 12 per cent. must have been detected or would be so nauseous that it could not be supplied.

15,112. (*Chairman.*) Have you ever drank a mixture of fresh and sea water?—I have taken it sometimes involuntarily when I have been bathing, but I have not tried a course of experiments to ascertain how little I could taste.

15,113. (*Chairman.*) In plain English, do you know any more about it than any of us here?—No, not at all.

(*Mr. Webster.*) Now you made a very remarkable statement in answer to question 13,863, when you spoke of the chemical composition of the water in the river.

15,114. (*To the Chairman.*) I have said, my lord, that I did not want to put unnecessary questions; but if I have to comment upon these matters afterwards, I hope it will not be said by my learned friends that I have abstained from touching upon various points, because I have, in deference to the views of the Commission, abstained from asking questions upon points with which, as far as argument is concerned, I can deal hereafter. (*To the witness.*) Now you have stated in answer to question 13,863, "Now comparing that," that is to say, the water at North Woolwich, "with the filtered water delivered by the water "companies for drinking purposes in London, the water here is nearly as pure." I see you have given the organic carbon; do you represent that organic carbon is what determines the fitness or the purity of the water for drinking purposes?—No, I was going on to give the organic nitrogen when I was stopped.

15,115. I really do not think you were, if you will pardon me for saying so?—Yes, that was so. Lord Bramwell asked me the question. He said at 13,866, "What have we to do with what water the people "are drinking." I was obliged to take all these things briefly.

15,116. Just tell me what the organic nitrogen was; was it ·123?—Yes; I have stated that before.

15,117. But what is the organic nitrogen in the water delivered by the company?—It is ·09.

15,118. You do not suggest that the ·09 is the ordinary average of water delivered. You say that that is the highest you have got?—I gave it as a measure of the state in which the river was.

15,119. Let me look at the table of organic nitrogen that you have got, if you please, showing anything as high as ·09. I am told the average is ·03?—I have a great many much higher than that. Upon the 20th of March, 1883, this present March, the water drawn from a tap of the West Middlesex as delivered by them contained ·099 of organic nitrogen.

15,120. Whose report is that?—The report of Dr. Tidy, Dr. Odling, and Mr. Crookes.

15,121. I see in your answer to question 13,863, "Now comparing that with the filtered water "delivered by the water companies for drinking pur- "poses in London." Do you mean to represent that as the average or the maximum?—I meant that as representing the water which was delivered occasionally by the water companies.

15,122. ·03 is the average, is it not?—That I cannot tell you. I have several here which are very much higher.

15,123. I should like you to give me the average of what you have got?—I have taken out the high ones, and therefore they would not be the fair ones to give.

15,124. Now I put it to you at once. Taking the organic carbon, taking the organic nitrogen, and taking the other chemical constituents, do you represent that the water at North Woolwich was as good as that delivered by the water companies?—What I do say is that the water at North Woolwich upon that day, which is the day when it is stated to be exceptionally bad, and therefore we are not taking the average of the Thames. I say that the water of that day at North Woolwich contained no more organic carbon than the water which is filtered and delivered, and 75 per cent. of the organic nitrogen.

15,125. As usually delivered?—No, as occasionally delivered.

15,126. I think I may be pardoned for putting this to you. You have quoted Dr. Frankland, at question 13,889, as suggesting that four-fifths of every drop of rain, however slight, goes into the sewers. Now I ask you either now or at any other time, because I know Dr. Frankland's view about that, to point out any answer in which he said anything of the kind?—It is his report as put in.

15,127. Can you refer us to any passages of it?—He refers to table C., and he says he has calculated in table C. the rain falling upon 122 square miles, and he has deducted 20 per cent. to allow for evaporation, and has taken four-fifths of the whole. If you turn to table C. you will see, as I mention, that when one-hundredth of an inch of rain falls, he, acting upon this suggestion, has assumed that the increased quantity delivered by the sewer would be 14,000,000 gallons per day.

15,128. I put it to you, as Dr. Frankland explained to my learned friend Mr. Bidder, is it not a table prepared upon the give-and-take principle, that when there is a much heavier rain the same principle is taken?—No, it is all give and no take. Every quantity is taken out and multiplied into the quantity of solid matter increasing in geometrical ratio.

15,129. You called attention to Mr. Mansergh's diagram of the condition of the river at Erith?—I am not aware that he put in any such diagram.

15,130. At question 13,930 you say "A longi-"tudinal section of the river was put in by "Mr. Mansergh." Now will you listen to this, you agree, do you not, that with the Dagenham shoals removed, without the mud upon the south side, the river was larger in its section in Halfway Reach than was required, that is to say, larger than the cross section below originally?—I agree with that.

15,131. Do you also agree that in 1878 when the mud was there, the cross section of the river was too small, however the mud got there.

(*Chairman.*) How was it too small.

(*Mr. Webster.*) That there was a larger section above it.

(*Chairman.*) You mean that actually and in fact it was not big enough.

15,132. (*Mr. Webster.*) That actually and in fact the cross section of the river and the water space was smaller than the sections above it considerably. (*To the witness.*) Do not you agree that measuring the cross sections in Halfway Reach in 1877, with the mud, the river was constricted at that point?—Not at the southern outfall itself.

15,133. At the same corresponding point, if you please, that Mr. Mansergh referred to?—Then I do not know what exact point he did refer to. (*The witness referred to his diagram.*)

15,134. You know the mud constriction to which Mr. Mansergh refers well, do you not?—The section does not give me that information.

15,135. Is there shown upon Mr. Mansergh's section a constriction of the river in the year 1878, where previously there had been no constriction?—It shows the accumulation of the mud.

15,136. And a constricting of the area?—It is less than it was before, of course.

15,137. In 1882 had that become still smaller?—That I cannot tell you from my own kowledge.

15,138. You see Mr. Mansergh's diagram showing that it becomes smaller. Do you say it is not correct?—I will not say it is not correct.

15,139. Assuming that it becomes smaller, does not it follow that that deposit must be of such a character that if the floods should sweep it away it would re-deposit in the ordinary currents?—No, because at the point where the largest accumulation has taken place the velocities of the current is even now far too weak; the area is too large. Although there are one or two points where there is a stronger current for a short length it is not sufficient to affect the deposit upon the south side.

15,140. You have not followed me. I should have thought your answer was the strongest proof that whatever were the strength of the currents, assuming the floods were sufficient to wash the deposit away, the deposit would be re-deposited in the ordinary currents afterwards?—I do not understand the question. The section before Sir John Coode will show the currents, and though there are one or two points where the stream is strong, it is not sufficient to prevent a deposit upon the south side where that stream does not run.

15,141. Are you not aware that the cross-section in 1882 is smaller than the area of the section before the dredging of Dagenham shoal had been commenced?—I cannot tell you that.

15,142. Assuming Mr. Mansergh's diagram to be true, that is so, is it not?—I do not know; there is no date showing when his normal bed of the river was taken. I am sure that cannot have been taken before the Dagenham shoal was removed; that is to say, that the line in black shown upon Mr. Mansergh's cannot be the line of the section of the river before the Dagenham shoal was removed.

15,143. Can you give me the area of the river before the Dagenham shoal was removed?—I have put it in, in a table and a section also.

15,144. (*Sir John Coode.*) Where is that?—It is on page 14 of the second day's evidence.

15,145. (*Mr. Webster.*) Which is the one you say shows the cross-section before the Dagenham shoal was removed?—My diagram No. 10 shows that.

15,146. Will you give that to me in square feet. I put it to you that the cross-section in the autumn of 1882 is smaller than you make it. You say it is not so. I can test it very well if you will give me what was the area of the cross-section in square feet prior to the Dagenham shoal being removed?—The area in square feet at half ebb was 40,927.

15,147. That, you say, is prior to the removal of the Dagenham shoal?—It is prior to the removal of Dagenham shoal.

15,148. That is D.D. upon your diagram?—Yes.

15,149. What do you say is the actual area at D.D. now at half ebb?—It is somewhere about 56,000 or 58,000; I am not sure exactly how far it corresponds with my No. 29 or No. 30; No. 29, which is the southern outfall, is 56,501, and No. 30 is 58,545.

15,150. But I am asking you about D.D., a corresponding point. You have put D.D. upon your own table?—Yes, but I have not got the present area of D.D. exactly until I have the line corresponding to it in the cross-section.

15,151. Do you say D.D. corresponds with Mr. Mansergh's cross-section?—He has not given a cross-section.

15,152. But you must see the necessity of making it clear to me.

15,153. (*Sir John Coode.*) Does Mr. Mansergh give the areas?—He gives the relative cross-sections, but I do not think he gives the areas.

15,154. I understand you to say it is somewhere between 56,000 and 58,000; is that your answer?—Yes, that is it; but I can give it exactly to-morrow

*Mr. H. Law.*
12 June 1883.

(*Mr. Webster.*) I will take that; but it does not follow because you take 56,000 here and 58,000 there that the particular point would be between the two.

(*Witness.*) I will give it exactly to-morrow.

15,155. (*Sir John Coode.*) You know the point if Mr. Webster wishes to have it?—Yes, I do.

15,156. And you will give it him to-morrow?—I will.

15,157. (*Mr. Webster.*) You have said that the sewage is discharged into 261 times its bulk; that is in answer to question 13,855?—Yes.

15,158. That statement is upon the assumption that it goes into perfectly pure water, is it not?—No, into the river water as analysed by Dr. Frankland.

15,159. I do not think you mean that?—I do mean that.

15,160. You say it goes in as 1 to 261, taking the water as it is?—Yes.

15,161. That is your statement, is it?—Yes; I say the sewage bears a ratio to the quantity, which passes upon an average tide of 1 to 261.

15,162. But that is assuming for the purpose of comparison that it is pure water that it goes into, is it not?—Certainly not; my argument is this: Dr. Tidy says, it is sufficient to have 20 parts of pure water, and I say that that water is sufficiently pure to allow 261 parts to do the work which 20 parts of pure water would do.

15,163. That, taking its impurities, 261 parts will do the work of 20 of pure water?—No, I do not say that, but you must take my whole argument.

15,164. We must have it one way or the other. Do you mean by your 1 to 261 that it goes into 261 times the quantity of water which will do the same amount of work as Dr. Tidy's 20, or do you mean that it requires as 261 is to 20 to do the same amount of work?—What I mean is, that, assuming 20 parts of the water delivered by the water companies to be sufficiently pure to purify the sewage (because we have no distilled water in the Thames, and Dr. Tidy, when he says "pure water," does not mean "distilled water,") 261 parts of the water of the river will do it.

15,165. (*Sir John Coode.*) I understand Mr. Law's argument to be, that he has got 13 times the quantity of fresh water which Dr. Tidy considers sufficient. (*To the witness.*) Whatever may be the value of that argument, that is it, is it not?—Yes, that is it.

15,166. (*Mr. Webster.*) I am told I ought to put to you question 13,788, in which you refer to the rate of traverse of the water on the 7th of September. How is that calculation arrived at; is it by taking the quantity of water on the 14th and working backwards?—Yes.

15,167. Now, if you had worked from the 22nd back to the 15th ——?—I have nothing to do with the 22nd.

15,168. I am only dealing with your own proposition. If you had worked from the 22nd back to the 15th, that would have shown a very different result, would it not, because you had 109,000 coming over on the 15th?—Very likely; but I have not gone into that at all.

15,169. (*Sir John Coode.*) Was that assumption of a week based upon any facts at all approaching the state of things which really exists?—No.

15,170. It was a pure hypothesis?—It was merely to show this, my argument was, that to take that day's fall over Teddington Weir is obviously wrong. If you went a week back that would at once reduce the quantity of sewage by half.

15,171. But supposing you went three days back, what would you find then; it would all turn upon your assumption of the week being correct or not?—Yes, and depending upon a great number of other circumstances as well as what the quantity of water coming down is.

15,172. If you had taken any other dates you would have had a very different result?—Yes, certainly. It all goes to show that the calculation is of no value.

15,173. (*Mr. Webster.*) I notice you have given some evidence about the mud; you have read a report of the state of the river in 1839; have you from any actual observations of your own, or is that what the chemists are going to say, gone into the question of what the mud is made of at Erith?—Not into its chemical composition.

15,174. Do you represent that it does not smell any more than common mud?—I represent it has no smell at all, unless you take it out of the sewers which are trickling over the surface; even on warm days it has no smell whatever, but that is a point upon which, of course, the Commission can judge for themselves; it has merely the smell of earth.

15,175. With regard to your evidence in answer to questions 13,960 and 13,961, as to the condition of the river in 1839 and the draining of the houses into cesspools, what number of sewer outfalls were there in 1839, do you know, above London Bridge?—I do not know that.

15,176. Were there not 140 in the year 1828?—There were a very large number of sewers, but you must bear in mind those were all sewers which had been there for 100 years to drain the streets; it does not follow that they came from the houses.

15,177. But what I put to you is, were not they sewers which, as far as one can gather from the reports, were discharging sewage matter?—To a certain extent. At that time it was illegal to put sewage into the sewers; it was contrary to the law, but nevertheless they did it surreptitiously; all the streets were sewered, but they were not intended to take house sewage.

15,178. (*Sir John Coode.*) As a matter of fact, they did take house sewage?—Yes, to a certain extent.

15,179. (*Mr. Webster.*) You mentioned the refuse from water-closets being carried in surreptitiously, when were water-closets invented by Bramah, was it in 1778?—No, it was later than that; I remember Bramah very well, and I was not alive in 1778.

15,180. But it does not follow that he died immediately after he had invented the water-closet?—It was much later than 1778 that they were invented.

15,181. Do you gather that there is the same rainfall in the upper Thames as in the lower Thames?—Certainly not. I have given you the relative quantities taken from Mr. Symon's table; I took his figures.

15,182. (*Prof. Williamson.*) There is one matter upon which you would, perhaps, be kind enough to give the Commission some further explanation than you have given us yet, as to the way in which you have obtained your figures in relation to the water which you conceive to percolate through the chalk into the river. With regard to the opinion you have expressed, that water enters the Thames as filtered water, which has fallen upon the chalk at distances from the Thames, and which is prevented from escaping elsewhere, on account of the gault, which underlies the chalk, you have included in your estimate of the water which is likely to reach the Thames (of course making allowance for evaporation) a good deal of that area which is beyond the actual valley of the Thames, have you not?—No, I have not used those areas in any way in my calculations. I mentioned the area simply to illustrate the large area which led water either to the Thames or to the sea. What I did to determine the quantity was this. I took the quantity over Teddington Weir, which contains that which comes in from springs in the upper part of the river. I then found that after making allowance for the difference in rainfall, the quantity gauged was not more than half below what came off above; that was the result of my calculation. Then from those data I determined the quantity which would come into the river, but not by taking any area, and assuming a percentage of the rain which fell upon that area as coming out.

15,183. But I thought in your answers to cross-examination you had referred to the gault as giving the limit within which the water was, to some extent, available for the Thames?—No; you will find that

I say that enormous quantities of water falling upon that area find their way to the sea.

15,184. Are there not other rivers than the Thames within the basin of the Thames?—Yes, there are.

15,185. (*Sir John Coode.*) That is to say, outside the Thames watershed proper, but within the area of the gault?—Yes, that is so; and you will find that the whole of these rivers are very small compared with the area of the country they drain. If you take the size of the bridges in the chalk country you will find they are nothing to compare with what they are in the clay country, and you will find that many of them owe their origin to the water that flows down the upper end of them from the clay. You will find that a very large proportion of the chalk country has very little water in it, nearly the whole of the water being absorbed, and only small rivulets existing.

15,186. (*Mr. Webster.*) Would you tell us what the Dart and the Cray are alone. Do you know that the Dart and the Cray are 5,000 cubic feet a minute, which, according to your own account, would drain 200 square miles?—They drain a very large area. There is a break in the centre ridge of hills, and the Darenth runs through, and takes the large area adjoining the Medway. It is very remarkable that the ridge is broken, and that the rivers, the Mole, the Darenth, and the Medway, all go through the fracture in the ridge or backbone that goes through the country.

Re-examined by Mr. Norman Bazalgette.

15,187. I will just ask you a question about the condition of the mud below the outfalls. As a matter of fact did you examine the mud below the outfalls as recently as last Saturday?—I went down the river last Saturday.

15,188. Will you state what the weather had been for some time preceding your visit to the outfall?

(*Mr. Webster.*) This does not arise out of my cross-examination.

15,189. (*Mr. Norman Bazalgette.*) You asked the witness whether the mud smelt, and I am going to ask how it was upon that occasion. (*To the witness.*) What had been the condition of the weather previously to that?—It had been dry weather for some time, and was very warm. We carefully took up the mud in front of the Corinthian Club at Erith, and from every place where it had been described as being derived from the human frame. A very large portion of it was lying there, and there was no smell in it whatever, except the ordinary smell that you have in mud.

15,190. (*Sir John Coode.*) What time of the tide was it you took the samples of mud?—It was low water.

15,191. And at what distance from the low water edge?—All the way up where we could find it.

15,192. All the way up beyond high water?—There is no mud beyond the high water. We had also an excellent view of the springs of the chalk water running out at Erith, a very excellent view indeed of them which the Commission themselves will have whenever they go to see the river at low water.

15,193. (*Mr. Norman Bazalgette.*) Did you see any bubbling out through the mud?—Yes, out through the sand, rather. There is a large quantity of bubbling through the sand, which I believe to be air and not noxious bubbles,—bubbles of air which I think does arise from the difference of pressure of the water at high and low water.

15,194. My learned friend asked you a good many questions about swallow holes and subterranean springs which find their way into the Thames; but I will ask you, even assuming you are not quite accurate as to the area in which you say this subterranean water arises, is it a fact that there is a large area from which subterranean water finds its way to the Thames?—Yes, but I repeat that I gave the area only as that which gave part of its water to the Thames, because I said an enormous part of it went to the sea; but I say it is the water which flows down the Thames basin and charges the chalk which I am considering.

15,195. I think you have told us that in order to make the chlorine tests of any value whatever, this subterranean water ought to be taken into account?—It should.

15,196. Has it been taken into account?—No, and the great importance of that is, in the dilution of the sewage with pure upland water.

15,197. Now, you were asked with regard to question 13,661, upon what data you say that 180 feet a minute represents a high velocity, what do you say to that?—We consider 120 feet through the sewers is a very good velocity.

15,198. Is that known to be a self cleansing velocity?—It is known to be a self cleansing velocity.

15,199. And if 120 is held to be a self cleansing velocity, 180 is a high velocity?—Yes.

15,200. Now about the number of storm overflows indicating the non-capacity of the main drainage system; my learned friend asked you how you could say that the main drainage system was sufficient as it was estimated in the first instance, having regard to the number of storm overflows which have been recently added to it?—To that I say that they are not so much storm overflows as relief sewers, extending a considerable distance inland.

(*Sir John Coode.*) But relief sewers into the Thames, else I do not see where they could go.

15,201. (*Mr. Norman Bazalgette.*) As a matter of fact, have not many of the natural water courses which formerly took the rainfall now been filled up?—Yes, as for instance, the Effra and the Hackney brook.

15,202. Therefore it has been rendered necessary to substitute artificial watercourses for them?—Yes, as they have built over the old streams and occupied their sites, it has been found necessary to provide relief sewers in place of the old natural brooks, that has been found necessary in the case of the Quaggy, the Hackney brook, the Effra, and others.

The witness withdrew.

Mr. Edward Easton examined.



15,203. (*Mr. Norman Bazalgette.*) I need hardly ask whether you are a civil engineer?—I am.

15,204. Are you well acquainted with the River Thames below London?—Yes, from the fact that for the last 25 years I have acted as engineer for the Commissioners of Levels extending from Woolwich to Gravesend for the preservation of the banks. I am also engineer to the Commissioners of the Navigation of Dartford and Crayford Creeks, and as such I have constant opportunities of inspecting the banks of the river, and of knowing what is going on on the banks and the beach, and on the shore of the river generally.

15,205. You are also engineer to the South Essex Waterworks Company?—I am; that is, on the north side of the river at Grays, and I have also constructed works at Gravesend for the supply of Gravesend with water.

15,206. I believe you have designed and constructed a good many engineering works of different kinds on both sides of the river?—Yes, I have had several other works under my charge, the pier at Grays, for example, and other works of a different character.

15,207. The first question I will ask you is this: in your judgment, are the positions which have been selected for the outfalls of the drainage of London suitable positions?—It seems to me that at the time these works were designed no more suitable positions could possibly have been found, and I do not think

*Mr. E. Easton.*

12 June 1883.

that the circumstances have so far changed as to lead one to change one's opinion. The river the whole way below Barking is bounded on both sides for a great distance by wide marshes, and, until you reach the town of Erith on the one side and Purfleet on the other, those marshes are generally from one to two miles broad. At the time that the outfalls were made there was scarcely any habitation whatever of any consequence, except at Gravesend, on the banks of the river, and it appears to me that therefore this site was chosen with great judgment. Besides this, from time immemorial, I may say, there have been a variety of, one cannot call them anything else but stinking trades, established upon the banks of the river between the two points Greenwich and Purfleet, and for that reason, if there should be any extra nuisance which would perhaps be inevitable from the discharge of the sewage of so large a city as London, it would become to a very great extent modified and, in fact, overpowered by the other nuisances which are already existing there. And for that reason I say that, in my judgment, the sites were well chosen.

15,208. I believe that since the outfalls were established Erith has enormously increased both as regards population and buildings?—Erith is the first point at which the high ground touches the river, before that, the shore of the river and its banks are such as I have described, but at Erith the high ground touches the river, the country is very beautiful, and there the population has increased, as the Commission know very well, and a certain class of residential property has sprung up both at Erith and between Erith and Woolwich, which has changed the general character of the population from that which I have just before described.

15,209. Can you tell me whether in the neighbourhood of Erith especially there are a number of these nuisance factories of which you were speaking just now?—There are a great number, as has been given in evidence; they are well known to me, because I have to pass them frequently in making my inspections upon the river.

(*Sir John Coode.*) We have only heard of one at Erith.

(*Mr. Norman Bazalgette.*) I put it to the witness "in the neighbourhood of Erith."

(*Witness.*) I am speaking of what we call the Erith Marshes, which extend from Woolwich to Erith.

15,210. (*Mr. Norman Bazalgette.*) Now can you tell me what is the sanitary condition of Erith as regards its own natural drainage?—I think the Commission have before them a report, which I made in 1877 and 1878, as regards the sanitary condition of Erith. The works which I recommended in that report have not been carried out, and I am not aware that the condition of Erith has improved in any way.

15,211. (*Sir John Coode.*) You think the state of things you described at that day has not improved at the present day?—No; probably they are aggravated by the increase of population. I have not been consulted about the matter since, but at that time the condition of things, especially in the lower part of Erith, was deplorable. The works which I recommended ought certainly to have been carried out.

15,212. At that time all the sewage from the town of Erith was discharged into the river?—The whole of the drainage that was turned into the sewers went straight into the river, and sooner or later the overflow of the cesspools would have got into the river. As a matter of fact, the town was then drained into cesspools in the lower part, but all the drainage proper went straight into the river and does to-day. I saw it the other day myself.

15,213. (*Mr. Norman Bazalgette.*) How many outfalls are there now?—The same number as existed at the time of my report; three or four, I think it is.

15,214. I believe, to put it shortly, you recommended that a proper system of sewerage should be carried out, and deodorizing works put up?—Yes, I recommended, after careful consideration, that we should put up deodorizing works at Jenningtree Point, just above Erith, and then discharge the sewage into the river; that could have been done without any offence whatever.

15,215. Is the discharge of sewage at all times of the tide into a bay like that at Erith objectionable, in your view?—Certainly it is. On Monday week I was there when the sewage was being discharged, and, owing to the iron pipe of one of the outfalls having been broken, the course of it was very observable. It was not a very large quantity, but it was very objectionable. I may say that in Erith Bay at every tide there is a dead water established when it is especially objectionable; as a matter of fact, on Monday week when I was there, I could see particles of the sewage floating about, certainly not Metropolitan sewage, which was going clean past the Bay, as I ascertained when I was in a little boat, but the sewage from the sewers themselves was floating about there.

15,216. (*Sir John Coode.*) How could you be sure that the sewage you saw was not sewage from the Metropolitan sewers?—It was not fresh from the outfalls.

15,217. But what you saw was the sewage which was fresh from the outfalls?—Yes.

15,218. You judged by the appearance?—I did.

15,219. And you judged that the sewage from the Metropolitan outfalls by the time it had travelled so far would have assumed a different appearance: is that so?—I say that the sewage from the Metropolitan outfalls was going quite past, it was not coming into the bay at all. We could prove that by the floats we put in.

15,220. Are you quite sure that those were not off-shoots from the Metropolitan outfalls which got into the bay?—"To be quite sure" is a strong term to make use of, but I think I may say I am sure of it.

15,221. (*Mr. Norman Bazalgette.*) You actually saw the Erith outfalls in operation that day?—Yes, I did.

15,222. I believe you can confirm the fact that Erith is not an unhealthy place?—It is not an unhealthy place, decidedly.

15,223. If the health of Erith were not all that could be desired, would you rather attribute it to the Metropolitan outfalls or to the sanitary condition of Erith itself?—I should attribute it rather to the sanitary condition of the place itself.

15,224. With regard to the accumulation of mud which is said to have occupied Erith Bight, how do you account for that?—With regard to the accumulation of mud, I may say from observation, I cannot say from absolute measurement, that I am not aware that there is more accumulation now than there always has been, varying as it does at different states of the river in that place, and the accumulation of mud which is there arises from the fact I mentioned that certainly at every tide for a length of time, varying, say, from one and a half to three hours, the water there is in a state of rest. When I was there on Monday week, the eddy, if anything, was flowing up the bight, but, as a matter of fact, the yachts which were in Erith Bight were heading any way.

15,225. (*Prof. Williamson.*) When you said just now that there was not more accumulation than there had been for some time, I do not know which of these two things you meant, whether the actual quantity there was not greater than it was some time ago, or whether the rate of deposit was not greater?—Taking the Erith causeway and the front of Erith, I do not think there is a larger accumulation of mud than there was.

15,226. The deposit every year is not greater than it used to be?—It is being deposited and washed away, changing and changing.

15,227. In your opinion, is not there a gradual increase?—In my opinion there is not a gradual increase.

15,228. (*Sir John Coode.*) Are you aware that we have had evidence that the accumulation at Erith is greater than it was formerly, and that that increase

has led to the lengthening of the slipway, and to the necessity of cleaning the mud from the top of the slipway ?—I am not aware of that.

15,229. (*Mr. Abernethy.*) And that it was also given in evidence that certain mooring buoys, that were formerly afloat at low water, were now aground upon the mud?—That is not within my knowledge. I may also say that at the mouth of Dartford Creek, though the mud banks have shifted, there is no more accumulation than there was.

15,230. (*Sir John Coode.*) You have more familiarity with the mouth of Dartford Creek than you have with this particular causeway, have you not?—Yes, I have perhaps, although I know Erith Causeway very well.

15,231. (*Mr. Norman Bazalgette.*) I do not know whether you are a resident at Erith ?—No, I am not.

15,232. But, as a matter of fact, Messrs. Easton and Anderson's works, in which you are or were a partner, were at Erith, were they not?—Yes, but I was not there very frequently, and I am no longer there. My information is more derived from the fact that accumulations of mud upon the shore and the banks would be reported to me by the Inspector to the Commissioners of the Levels.

15,233. What would be the remedy to get rid of those accumulations, in your judgment?—That is another matter altogether; that would only be by altering the shape of the river, but there is no doubt that the mud shifts from tide to tide.

15,234. (*Sir John Coode.*) It comes and goes, you mean?—Yes, it comes and goes; there is no doubt about it, according to the state of the tide and the quantity of water coming down the river.

15,235. (*Mr. Norman Bazalgette.*) I believe you have made yourself acquainted with the evidence which has been given with regard to the chlorine experiments ?—I have read the evidence relating to the chlorine experiments. *Mr. E. Easton.* 12 June 1883.

15,236. What do you say to that?—As far as I can follow the argument, I must say it is not to my mind at all conclusive, or worth very much, for this reason that, in the first place, it must be almost impossible to take samples enough to show what the chlorine really is in the river, and then, in the next place, it comes to so fine a point that the admixture of the fresh water, which Mr. Law has mentioned, all the way down the river, would have the effect of upsetting the calculation to a very great extent. The water which has been referred to does, as a matter of fact, issue into the river the whole way from Deptford to the sea; it can be seen at a great number of places, and the quantity is very large indeed.

15,237. (*Sir John Coode.*) You say it can be seen all the way from Deptford to the sea?—Yes, I have no doubt of it; it runs out just below Deptford. The chalk is denuded in the river just below Deptford, and it is no doubt exposed in the bottom at many points between Deptford and Gravesend. The water is running out at various places, though not all the way along; at Woolwich it does not get out, but all the way along, with exceptions, there are springs issuing into the river.

15,238. Visibly?—Yes, there is a very large amount coming in at the Greenhithe marshes, and at other places; at Grays, for example.

Adjourned to to-morrow at half-past 12 o'clock.

# FORTIETH DAY.

## Wednesday, 13th June 1883.

PRESENT:

SIR JOHN COODE, MEM. INST. C.E., IN THE CHAIR.

COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
THOMAS STEVENSON, ESQ., M.D.
WILLIAM POLE, ESQ., F.R.S., *Secretary.*

Mr. EDWARD EASTON called again; further examined by Mr. NORMAN BAZALGETTE.

(*Witness.*) I think in the last few questions that were asked me by the Chairman yesterday, there was a little misunderstanding as to what I meant by there being no accumulation of mud in Erith Bight. In the former part of my evidence you will see why I show that there must have been a certain amount of mud bank in the Bight. What I referred to was the shore of the river. I was speaking of the shore of the river all the way down, and I said, if I remember rightly, that I should have heard if there had been an accumulation of mud on the foreshore of the river, from the people who have charge of the banks. You asked me a question indicating that you thought that my evidence was conflicting with the evidence of the people in Erith. What I say is, that there is no more accumulation of mud on the shore than there was——

15,239. (*Chairman.*) You are speaking of Erith Reach as a whole?—Yes, that all round Erith itself there is no accumulation of mud upon the shore. There may be a bank formed by the eddy which I explained, and there is a bank no doubt formed, because it is given in evidence; but what I referred to is the absolute shore of the river. There is no more deposit, as far as I know, upon the shore of the river, underneath what they call Erith Hard, than there was a great many years ago, certainly not more than there was in the year 1877 when I made my Report; because, as will appear by the next part of my evidence when I went down the river I walked upon that very ground.

15,240. (*Mr. Norman Bazalgette.*) I believe you have a plan showing the exact amount of increase, if any, which has taken place between the years 1862 and 1872?—That is at Dartford. Sir John asked me whether I was prepared with more particular evidence about Dartford Creek, and I had then in the room and I have now made a copy of a plan which shows the difference of the line of mud bank between 1862 and 1879, when I was making certain surveys for the improvement, the canalization in fact, of Dartford Creek. This plan (*handing in a plan*) shows the line of mud in the year 1862 when it was surveyed by the Ordnance, and the present line of it. As a matter of fact, I believe it has not changed at all in all those years. 13 June 1883.

15,241. (*Chairman.*) When you say it has not changed, do you mean as far as you could judge by appearance. This "February 1879" upon the plan, I suppose, is actual survey?—Yes, that is so.

15,242. Do I understand that what you mean by that remark is that it has not changed in all those years, between 1879 and 1883?—No; that it has not changed between the years 1862 and 1879. I mean that in the interval there is no reason for supposing there was any change. That of 1879 was a survey made for the purpose of the canalization of Dartford Creek.

15,243. It is rather a question of what it may be now?—Since 1879 I cannot tell you what it is.

15,244. (*Mr. Norman Bazalgette.*) I believe you

*Mr. E. Easton.*

13 June 1883.

went down the river with the view of making an inspection of it upon the 4th June last?—Yes, that was Monday week.

15,245. Now, will you state what you observed upon that occasion, and what you did?—I went with Mr. Chatterton and with another gentleman in the employ of the Metropolitan Board of Works, who had been in the habit of taking samples, I believe; we started from Westminster Bridge at 11 o'clock.

15,246. (*Chairman.*) What was the state of the tide then?—It was a rising tide.

15,247. Was it nearest to low water or nearest to high water?—It was nearest to high water; we timed ourselves to be at high water at Barking outfall, and therefore it was nearest to high water; we had started at 11 o'clock. There was a sample taken of the water near Westminster Bridge, from which, of course, we could perceive no smell whatever; we steamed down the river and got to Barking outfall a little after high water, a little after the sluices had been opened.

15,248. When you say "a little," do you mean a few minutes or an hour and a half?—I can give you the exact times. It was half an hour as nearly as possible after the sluices had been opened.

15,249. You were going to speak of the time the sluices were opened. You say the sluices were opened a little after high water—how long after high water were they opened?—The sluices were really opened a little before high water upon that occasion. I was there at high water.

15,250. Do you know how long they had been opened?—The man told us he thought they had been opened about half an hour. The reservoirs were perfectly full at the time they were opened, and when we saw them they were reduced 1 foot 6 inches, and that would have taken half an hour to empty. We landed and saw that the outlets were opened, and we took a sample from the outlet culvert itself.

15,251. You are speaking of the Barking outfall now, are you not?—Yes, I am. We were then in the middle of the sewage in a small boat, and, of course, it was not very pleasant. We then went across to the other side of the river to have our lunch, and to give time for a certain quantity of the sewage to go out, and we went back again and put in a float.

15,252. What was the state of the tide then?—It was then 2.46 p.m., that is to say, it would have been ebbing one hour and a half, or from that to two hours.

15,253. You may call it the first quarter ebb?—Practically it was the first quarter ebb. The float was put in, and we followed it in a small boat.

15,254. Were you in the middle of the river or near the shore?—In the middle of the sewage, close to the shore, close to the northern outfall, and we followed it down.

15,255. How far were you off the discharging point?—We were exactly over the apron, as near as we could tell, over the discharging point.

15,256. That is close to the outlet?—Yes; we were in a boat, as it were, upon the top of the outlet; the apron was then covered with water, but you could tell by the boiling up exactly where it was, and, as a matter of fact, I have no doubt that we were exactly over the outlet. The float was put in there. I have the exact time here when it was put in. I think I stated that it was at 2.46. The storage reservoir had by that time sunk down to 6 feet, that is to say, it had lost nearly half of its contents. At that time, I need not say, the smell of the sewage was very strong. There was an east wind blowing, or rather east by south, but every now and then, in fact I may say constantly, the smell even then of the chemical and guano works overpowered the smell of the sewage, so that you could not distinguish it at all.

15,257. (*Mr. Norman Bazalgette.*) Could you mention the works from which that smell proceeded? Law's Chemical Works I can specify particularly.

15,258. (*Chairman.*) An east by south wind would bring the smell from those works?—Undoubtedly. There was a sample of the water also taken there. We then followed the sewage in our small boat for about 20 minutes, until, in fact, one minute past three, or rather less than 20 minutes.

15,259. (*Mr. Lumley Smith.*) By "following the sewage" do you mean following the float?—Yes. You could see the float was in the middle of the sewage. There was no mistake about following the sewage, for it was absolutely in the middle of it.

15,260. (*Chairman.*) What was the character of the float?—It was one of the large floats, of which you have had a description, which have been used in the course of the inquiry. We followed the float until it was opposite the guano works pier, which are a little past Barking Creek, and are called the Barking Guano Works; they are past Laws' Factory, a little bit down the river below Barking Creek. We then left the float, going ourselves in the tug across to Crossness, leaving the small boat to follow the float, so that we might be sure where it was. We went, as I say, across to the Crossness outfall, and there we put in a float just opposite the place where the West India Docks are making their mud deposit upon the Erith Marshes. We put in another float there, which we also left. That float was put in at Crossness, and took a line parallel to the shore.

15,261. Was that float put in near the outfall at Crossness?—It was a little below the outfall; it was exactly opposite this mud wharf, which I speak of, of the West India Docks, which adjoins the Crossness works. The Chairman may know that the West India Dock Company have bought a small piece of land, and are bringing the mud out of the East and West India Dock in barges, and are depositing it upon the piece of land which they have acquired for the purpose.

15,262. (*Chairman.*) Is that between Johnson's Fish Manure Works and the Crossness outfall?—Yes, it is quite close to the Crossness outfall boundary.

15,263. (*Mr. Lumley Smith.*) Is it above it or below it?—Below it; between the outfall and Johnson's Works.

15,264. (*Chairman.*) Does it occupy the whole space between the south-eastern boundary of the Crossness Works and Johnson's Works?—Between that and the magazine. They have bought some more since, but I do not know the limits exactly; they are depositing the mud anyhow from the docks; and we put in the float just from the boundary, between the two, say, at the north-eastern corner of the Crossness outfall works.

15,265. Was it nearer to the centre of the river?—No; as I said before, it was in the flow of the sewage. You could see the line of demarcation as plainly as if you had drawn it upon the map; you could see it upon both sides. We then went from there across after the other float which, by this time, had got very nearly off Dagenham Jetty, upon the other side of the river, and from there we went to Erith Bight, and put in another float, which remained, as nearly as we could tell, stationary, whilst the float put in at the northern outfall had travelled half a mile, probably, beyond it.

15,266. What was the time of the tide at this period?—It was then at 20 minutes past 4, so that, if the other was a quarter ebb, this would be getting near half ebb; that float was, practically, stationary with the yachts.

15,267. Where did you put that float in; was it near the shore?—Yes, tolerably near the shore. I should think, as nearly as I could tell, about 120 yards from the shore; it was a long way within the line of demarcation of the sewage.

15,268. Do you mean up stream, or inside of Erith Causeway?—Up stream. It was put in just opposite the Upper Ballast Wharf, which I have indicated upon the plan. There a yacht, I think it was the Commodore's yacht, was facing up stream with the falling tide, while other yachts were facing in exactly the opposite direction.

15,269. Was there a strong wind?—Yes, there was a strongish wind the other way, an easterly wind.

15,270. Therefore they were wind-rode, and not tide-rode?—They were pointing in the opposite direction to the tide; they might have been wind-rode.

15,271. Or there might have been a counter-current; was there much wind?—There was not much wind; we went very near two of those yachts, disturbing them considerably with our propeller, and they nearly collided; they were very uncertain in their motion, and it took them a good deal of time to get themselves straight again, which, as I judged, would not have been the case if there had been any strong influence upon the yachts either one way or the other. As a matter of fact, I believe the float was in a sort of dead water at the time; that float was taken up again, as it was no good for any further experiment. We then went across after the Barking float, which had by that time (4.32) reached the mid-channel between Cold Harbour Point and Crayfordness; it was about mid-stream, opposite those two points.

15,272. (*Chairman.*) When you say "opposite those two points," that is a very oblique line. Do you mean about midway between those two points and mid-channel?—Yes; I meant in the line half-way between the two points; that was at 32 minutes after 4. At 4.46 the float was just in mid-channel, off Crayfordness, and there we took a sample of the water, and, as far as I could judge, there was no smell of sewage or anything else in it. The whole of the sewage from both Barking and Crossness had by that time, upon this particular day, disappeared entirely, and I do not think you could have recognised any trace of it by the senses. At 5.5 the Barking float was in mid-channel at the top of Long Reach, looking fairly down Long Reach, and there we took it up. As we were at Crayfordness we took a sample of the sand that three barges were dredging for. These three barges were exactly opposite Crayfordness.

15,273. (*Mr. Norman Bazalgette.*) What was the sand like?—I have not a sample of that sand with me, but it was a bright sand, covered on the top with a very small thickness of black material or mud.

15,274. I presume those men who were dredging were dredging for profit?—I presume they were. I know nothing about that.

15,275. (*Chairman.*) Was that near the shore?—It was near the southern shore, at Crayfordness.

15,275. Did you ask them for what purpose they were dredging the sand?—I do not know that we did, the sand was very much like that (*producing a sample*). It was pretty evident that the sand was being dredged for building purposes, it was sand that could be used for cement work or anything of the kind when it was washed.

15,277. (*Mr. Norman Bazalgette.*) Did you smell it at all?—There was not the slightest smell in it that I could detect when it was brought out.

15,278. (*Chairman.*) Was it a bag and spoon dredge?—Yes, that was a bag and spoon dredge.

15,279. Did you detect any smell when the spoon came out?—No.

15,280. (*Mr. Norman Bazalgette.*) Were those three men the only men you saw dredging for sand when you were down the river upon that occasion?—No, we took another sample when we were up at Cubitt Town afterwards; men at this point were dredging for sand.

15,281. And at other points you saw other men dredging for sand?—At two or three other points, but I will not specify the other points, except the one at Cubitt Town. We then went back to Erith and visited one of the Erith outfalls which I had not seen since I visited it in 1877 for my report; that was the one where the iron pipe was broken, and which was discharging sewage at about half tide upon the shore. We then went to Erith Causeway and landed, and took a sample of mud, which after being dried, produced that sort of stuff (*handing in a sample*). I have no doubt you will have this given more accurately, but this is an engineer's way of finding out what was in the mud; there is about from 40 to 50 per cent. as nearly as we could tell at a rough estimate, of that sand in the mud by the side of Erith Causeway.

15,282. (*Chairman.*) This sand has been washed, has it not?—Yes, it has been washed, and that is the product.

15,283. This is the residuum of a much larger quantity?—This is the residuum of about double that quantity in bulk; and of the rest a very considerable proportion you could see was coal dust and pieces of brick and different things. Having taken that sample of mud off Erith Causeway, I might say that we pushed a pole into the mud, and as far as I could judge, and I think I have a pretty acute smell, I could not detect any offensive smell from the mud on the pole, and I think that sample shows why that was.

15,284. Could you give us the position with regard to the Causeway where you did push this pole down?—It was in two or three places all the way along. It was then getting to near low water, it was at 5.45, and it must therefore have been near low water.

15,285. But at what point with regard to Erith Pier?—It was on the Causeway.

15,286. Is that the same thing as the pier?—No it is quite a different thing, the pier is there (*pointing to the plan*) and the iron pipe which has been spoken of as being broken, which is a small affair, is there (*The same was pointed out*).

15,287. Then Erith Causeway is near the "Crown"?—Yes, it is close to another outfall of the sewage, the Causeway runs out to low water. I think it has been given in evidence that it had to be lengthened at the lower part of it, but that is not the higher part of it, it is the lower part which they say has been raised. We passed down upon that and pushed the pole down into the mud. If I remember rightly, it was upon the western side towards the up side of the Causeway, but we tried it at several places walking along the Causeway from low water mark up to the edge of the shore, and a sample was taken as nearly as possible, I should say, 30 feet from the end of the Causeway, from the mud.

15,288. Have those samples been analysed?—I believe the chemists are analysing them. You will have reports upon them.

15,289. Unless they have been analysed, I do not know whether it is necessary to go into all these details?—They have been analysed.

(*Mr. Norman Bazalgette.*) The analysis will be put in by-and-bye.

(*Witness.*) They were very carefully taken and brought home for the purpose of analysis, and what I am giving you now is only a small portion of the sample to show that there is sand in the stuff. Now continuing my voyage, at the point at which I left it, near the Isle of Dogs, as we came opposite Cubitt Town there were some other men dredging for sand, and this (*handing in a bottle*) is a sample of what they got, which is a coarser description of sand. This was on the east bend of the river there opposite Cubitt Town Pier, very nearly opposite the Thames Soap Works and the Greenwich Candle Works. I have marked that sample "C. T."

15,290. (*Chairman.*) What proportion does this bear to the bulk of the sample from which it was taken?—I should think that that is about a twelfth or a fifteenth part of the sample; it was taken in a spoon and put into a jar, and then brought up and given to the chemists, and that was washed out for me to see what the sand was. I think you will find from the chemist that that would be about a twelfth or a fifteenth part of the total sample.

15,291. (*Mr. Norman Bazalgette.*) Did you notice the smells from the factories when you were there on Monday week?—Yes, you could not help noticing the smells from the factories, particularly of the fish manure factory on the opposite side of the river to Erith, you could smell that of course very strongly. It was an unfavourable day for smelling because there was a strong breeze, but you smelt it in a concentrated form I expect. But I know, as a fact, that

*Mr. E. Easton.*

13 June 1883.

you can smell all those smells at Erith and at other parts very distinctly; some of the cement works are especially offensive.

15,292. In your judgment, what is the effect of letting out the sewage at high water?—I think I have said already that the way in which the sewage is let out at Barking, is the best way that could possibly be conceived. High water, I need not explain to the Commission, takes the sewage, as we saw, straight away more or less in accordance with the time of the tide; at any rate it takes it straight down the river.

15,293. (*Chairman.*) You do not mean to tell us that the letting out of the sewage before high water, as you described just now, is the best mode of procedure?—I mean to say as it ought to have been let out, as the regulation is to let it out.

15,294. You would not advocate letting the sewage out before high water, I should think?—There might be certain times at which you would let it out before high water. It would depend very much upon the tide.

15,295. (*Mr. Norman Bazalgette.*) Respecting that answer you gave just now, I want to ask you this,—whether the percentage of the clean sand in the Cubitt Town sample does not amount to about 90 per cent. of the whole sample?—I cannot say that of my own knowledge, but you will hear more of that from the chemists.

15,296. In saying it was a fifteenth part, you did not mean to say that was the percentage of the clean sand?—No. The Chairman asked me what was the proportion of the sample to the whole sample, and I said that it was about a fifteenth part.

15,297. Assuming the sewage discharged wholly upon the ebb, is it in your judgment possible for any deposit to be made of the sewage in Erith Bight or any other part of the river?—I will not say "in any other part of the river," but I cannot see how the sewage from the metropolitan outfalls could be deposited in Erith Bight.

15,298. (*Chairman.*) Did not you say there was a counter current of slack water in Erith Bight, and might not that be the means of depositing the sewage there?—Not the sewage as it comes out of the outfall. What I mean is this, that the sewage, after it has been mixed up with the general water of the Thames by going down the river, may then come back mixed with water into Erith Bight; but that is a different thing. The sewage itself as it comes out of the two outfalls cannot go into Erith Bight.

15,299. I suppose no one ever imagined that sewage would be deposited in Erith Bight in a form as concentrated as that in which it left the outfall; but the question is whether a considerable portion of the sewage in the form in which it reaches Erith does not get deposited upon the beach?—That is not so. I think I am right in saying I do not think it could.

15,300. (*Professor Williamson.*) You say that sewage could not be deposited; but, after all, I cannot imagine that it is a question of the deposit of sewage. No one could imagine that sewage, which is a mixture of liquid and solid substances could be deposited. The only question is whether certain solid substances suspended in the sewage could, when the mixture was moving less rapidly, be deposited in the slack water?—You mean, I presume, by solids certain flocument animal or vegetable matters. I do not see how that could be from the sewage. I conceive that the sewage must be so mixed with the water that, in the shape in which you put it, I cannot see how that can possibly be deposited from the metropolitan sewers, and if there is anything of the kind in the samples, it must come from local causes.

15,301. That the deposit of animal matter at Erith must arise from the Erith drainage?—Yes, practically.

15,302. (*Mr. Norman Bazalgette.*) I think you told us when you began your evidence that, in your judgment, the position of the outfalls had been well selected?—I said so at the beginning of my evidence.

15,303. Do you think, having regard to the conditions and circumstances as they exist at the present time, that the present position of the outfalls could be improved?—That is a large question. I think that is going into the other part of the subject.

(*Chairman.*) The Commission have decided not to go into that at the present stage of our inquiry.

(*Witness.*) If you will put it between the two points that Lord Bramwell mentioned, Greenwich and Gravesend, I would say it certainly could not be improved upon.

15,304. (*Colonel Ewart.*) Did you look at the sewage in the tanks before it was discharged?—Yes, certainly. I went over the discharging culvert which came from the tanks. You cannot very well look into the tanks, but a sample was taken from the discharging culvert as it came from the tanks themselves.

15,305. As I understand, you did not see it actually flowing into the water? It was let in and mixed with the water below you?—It was all absolute sewage.

15,306. What was the appearance of it? Was there an appearance of solid matter, or was it very much diluted?—I know it could not be very highly diluted. There was a certain amount of solid, there was a good deal of debris, wood and straws and that sort of thing, and some brownish solids, which, no doubt, were excrement, as it came out. There was a very marked line where the sewage ceased. You could see immediately by the stuff that was flowing down the river which came out of the sewage, straws and pieces of wood, where the sewage line was.

15,307. You saw a clearly defined line, I suppose, which the sewage made?—Yes, a clearly defined line.

15,308. Could you trace that line far?—Yes, you could trace it as far as we followed it, certainly, and then it lost itself; and the same with the Crossness discharge.

15,309. You saw the Crossness outfall distinctly discharging before it mixed with the water?—Yes. We had not arrived at Crossness until, I think, two hours or more after it began to discharge, but still there was a distinct line travelling down parallel to the river, and then striking towards the shore, and joining the other line which came from Barking, and this in the face of a strongish easterly wind blowing.

Cross-examined by Mr. Beaumont Morice.

15,310. Do I understand you to say that the mud has not increased in Erith Bight recently?—No. I explained, when I came into the room first to-day, that there was a misapprehension about that. I do not know what the state of the mud is in Erith Bight itself, what I say is that the mud has not increased upon the shore in Erith.

15,311. What part of the shore are you speaking of?—I am speaking of the whole of the shore more or less, but I can speak especially of the shore below the outfall at the middle of those three sewers by the mill.

15,312. When did you last have an opportunity of seeing this mud?—The other day. Monday week.

15,313. Have you noticed it often during the last two years?—No. The last opportunity I had before that of making an examination which would be worth recording was when I was making a report about the sewage in 1878, I think it was.

15,314. I may take it that you cannot speak decidedly as to how much it has increased during the last two or three years?—I do not know what it increased, if it did increase, in the interval. I say the mud at the present time is no more than it was in 1879 on the shore.

15,315. Do you know anything about it further up the river than the mill which you mentioned? Do you know the Church Hole?—No, I do not. I did not go there.

15,316. You do not know that part?—No, not for this purpose. I know every part of the bank generally.

15,317. As far as the mud is concerned, you cannot tell whether that mud has increased in recent years or altered in quality ?—I cannot. I walked upon this hard for this purpose, the same as I did before.

15,318. (*Chairman.*) Is the whole of the beach in such a condition that you can walk upon it ?—Yes, you can walk upon it at that part, and you would not mud your shoes.

15,319. Would you say that it is all hard from low water upwards ?—No, certainly not, because we took our samples of the mud below.

15,320. Near the low-water edge ? — Yes, and further up.

15,321. What I want to know is, where upon the beach is this particular hard ?—It is just by the head of the causeway, close to the shore.

15,322. About how far did it extend as between high and low water—what proportion would it bear ? —It would be, perhaps, a quarter of the way to low water it is a wharf, in fact.

15,323. What is the extent of the breadth of the hard ?—It is not many feet.

15,324. What is the extent of the breadth of the mud ?—It is very considerable. I should think 150 feet.

15,325. (*Mr. Beaumont Morice.*) You talk about the beach, is there any beach there at all, in the proper sense of the term ?—I do not think I called it a beach.

(*Chairman.*) I think I said beach, and Mr. Easton spoke of the hard.

15,326. (*Mr. Beaumont Morice.*) As a matter of fact there is no beach ?—Certainly not.

15,327. When you say "the shore," I should like to know exactly what you mean by the term "shore"? —What I mean is the banks of the river, a sloping sea-wall, which slopes out a certain distance.

15,328. (*Chairman.*) You do not mean the foreshore ?—I do not mean the saltings.

15,329. But the foreshore is between the edge of the bank which you protect and the water ?—No, that is not so.

15,330. (*Mr. Beaumont Morice.*) At the part you mention, is there not a steep slope going down under the foreshore ?—Yes, there is ; it is a wall ; it is nearly perpendicular.

15,331. From that wall is not there a hard, in the strict sense of the term, that is to say, a built hard, extending out into the river ?—I think not ; not as far as I remember.

15,332. Is not this the hard that you walked down ? —I went on to the hard bottom, but I do not know how that was made.

15,333. What time of the tide was it ?—It was getting towards low water ; at all events, there was get mud on it.

15,334. How far down did you go upon the hard ; did you go right to the end ?—We went along the causeway from the boat, right up to the hard ; we traversed the whole ; we did not walk upon the mud ; we walked upon the hard, and then got off to see the outlet of the sewers.

15,335. Was there no mud upon the causeway ?— Certainly not. When you say "*no mud*," I do not know quite what you mean by the term. There were the remains of what the river itself would deposit ; there was not a quarter of an inch thick in any part ; I should call it no mud ; there was not what you would call a deposit of mud on the hard ; there was merely the deposit left by the river.

15,336. Did you notice what that was like ?—No ; it was not enough to pay any attention to ; it did not draw one's attention to it all.

15,337. Will you tell me the exact spot where you put this pole down ?—We put the pole down in three or four places along the causeway.

15,338. What depth of mud did you get ?—We put it down four or five feet.

15,339. No more than that ?—No, we did not push it down further ; I do not think the pole was long enough.

15,340. Did you put it down upon both sides of the causeway ?—Yes, we put it down on both sides of the causeway ; but I think it was generally put upon the shore side.

15,341. (*Chairman.*) I understand you to say that the pole was not long enough, and that was the reason you did not push it in further ?—There might have been any amount of mud below ; we did not go to the bottom of it, as far as I know.

15,342. (*Mr. Beaumont Morice.*) That was the mud you took samples of, was it not ?—Yes, we took samples of it ; two samples, I think, but one at all events ; that was the mud out of which the sand, in the bottle before the Commission, came.

15,343. I understood you to say there was no smell from that ?—There was a muddy smell from the pole, but no smell of sewage ; merely what you would expect to find if you poked it into a pond.

15,344. May I infer from that that there was no sewage there ?—No, I do not infer that at all. I infer that there was nothing offensive in the mud at that time.

15,345. Whether sewage or anything else ?—Whatever it came from, it was not a bank of sewage.

15,346. You referred to the drainage of Erith, which you made a report upon, and in that report you state that the sewage only referred to Erith proper ; do you know the extent to which houses in Erith are drained by sewage pipes ?—I have before me the way in which every house in Erith is drained, and not only in Erith, but in the whole district. I could give you, in detail, how every single cottage was drained, I think.

15,347. Is it your opinion that the sewage of Erith causes the nuisance of which the inhabitants complain ? —I do not know what the nuisance is to which you refer.

15,348. That the nuisance arising from the sewage outfall or drain of Erith causes the nuisance of which the inhabitants complain ?—I am obliged to repeat that I really do not know what nuisance the inhabitants complain of ; if they complain of smells, I can refer them to a good many stinks.

15,349. May I ask you if the outfall at Erith would be sufficient to produce a nuisance offensive to Erith ? —Yes, I think it might very readily.

15,350. (*Chairman.*) I understand you to say that you do not think it does. If I understand your view accurately, there is no nuisance at all there, whether from the metropolitan sewage or from the Erith sewage ; that is the impression your evidence has left upon my mind up to this moment ?—I think I said I saw some evidence of stuff on the day I was there floating about.

15,351. But not enough to create a nuisance ?—No, not upon the day when I saw it.

15,352. Then your view is that there is no nuisance ? —I do not think there is a nuisance in the river arising from sewage at all.

15,353. Whether from the metropolitan or the Erith sewage ?—No. I do not think you could smell Erith sewage quâ sewage. I had, perhaps, misunderstood the question of the learned counsel ; but I say that I do not think there is any nuisance coming from the sewage, and that is the reason why I asked what is the nuisance they complain of. The nuisance that I complain of in Erith is that there is not sufficient drainage ; that is all I complain of.

15,354. (*Mr. Beaumont Morice.*) You have mentioned about the factories ; can you distinguish between the smells of those factories ?—Some of them certainly I can. I am obliged to repeat my old friend the Fish Manure Factory.

15,355. Can you distinguish between the smells from factories and the smells from sewage ?—Sometimes you can. When we were in the middle of the sewage we frequently smelt the sewage alone, until, as I said in my evidence, the smell from Law's Works overpowered the smell of the sewage.

15,356. May I take it, speaking generally, that you can tell a factory smell from a sewage smell ?—I do

*Mr. E. Easton.*

13 June 1883.

not think there is any doubt about it. When once you have smelt the sewage smell and the factory smell you will be in no doubt about it.

15,357. And the people living in the neighbourhood of the various smells can tell it too?—I doubt very much, when other smells are mixed up with it, whether you could smell one more than another; but the smell of the sewage is certainly a distinct smell.

Cross-examined by Mr. Lumley Smith.

15,358. You told us yesterday that you had seen this stuff floating about the other day; is that the same occasion that you were speaking of when you spoke to-day of the 4th of June?—If you are referring to the small particles I said I saw floating about, it is the same occasion. I have seen it upon an occasion years ago, but this is the occasion I am speaking of.

15,359. With regard to the floats; you put in three floats, I understand?—I did.

15,360. One at Barking, one at Crossness, and one at Erith Bight?—Yes.

15,361. Those were the only three you put in?—Those were the only three.

15,362. With regard to the samples; those samples that you took, as I understand, were submitted to the chemists; is that so?—They were all sent to the chemists of the Metropolitan Board of Works.

15,363. Are they samples of water as well as samples of mud?—There are samples of water; we took a number of samples, and there were samples of water as well as samples of mud and samples of sand.

15,364. Did you label them in the boat?—Yes.

15,365. Do the labels show exactly where they were taken?—Exactly, and the times, and the temperature; we took them all.

15,366. (*Chairman.*) And the depth below the surface?—Yes, in every case.

15,367. Were they taken at one uniform depth, or at different depths at the same spot?—We took one sample at each spot, at a depth generally of two feet beneath the surface in each case. I am speaking now only of the water; but there was only one sample taken at each part, and not at different depths at the same spot.

15,368. (*Mr. Lumley Smith.*) With regard to the samples that you have brought here, the mud has been washed, I understand, and then baked?—One of them is a sample of mud.

15,369. But the process has been the same?—Yes.

15,370. First of all it has been washed, and then it has been baked or dried?—The water has been evaporated off it, and that is the dry residue; but the mud, in each case, has been washed off, you may say.

15,371. You spoke of coal dust; coal dust would remain, would it not, if it were here?—That was washed off; but there was very little of anything upon the top of that last sample you took up, marked C.T.

15,372. Now, with regard to the line of mud; this is the plan that you have handed in; that was made for what purpose?—That is the plan which was made for the purpose of my making a report for the canalisation of Dartford Creek, about the year 1879.

15,373. Which of those lines represents the line of mud in the year 1879, and which in the previous year?—The black is the line in 1879 and the blue one is taken from the ordnance map which was surveyed in the years 1863 to 1866.

15,374. Your map does not show which is which, does it?—Yes; you will find the blue line which is dotted, that shows what it was upon the ordnance survey.

15,375. That does not show much variation?—No, it is exactly the same.

15,376. Was not the year 1879 a very wet year; do you remember?—I do not remember.

15,377. Were not the years 1863 to 1865 very dry years?—I do not remember.

15,378. If you are comparing a dry year with a wet year, that will not be a fair comparison, because there is a great deal more water comes down the rivers Dart and Darenth in a wet than in a dry year?—No, not very much more, because it is one of the chalk streams and it is a tidal river as well; the quantity of water issuing from Dartford Creek depends a good deal more upon the tide than it does upon the quantity of upland water.

15,379. But it is only tidal just up at the mouth, is it?—It runs up inland as far as Dartford.

15,380. I did not quite understand when you told us that your third float that was put in at Erith Bight, and was stationary, was within the line of demarcation of the sewage; is that the sewage from the outfall?—From the Crossness outfall.

15,381. When you say "within the line of demarcation of the sewage," do you mean within the sewage?—No, the sewage was out far beyond it.

15,382. By "within" you mean not in the sewage?—In shore of it.

Re-examined by Mr. Norman Bazalgette.

15,383. The Thames water, I believe, contains a certain amount of suspended matter, part of which is of natural origin and part, no doubt, due to whatever suspended matter is contained in the sewage discharged into the river?—Certainly, and to the solid matter which has been washed from the bank.

15,384. You pointed out that in slack places the tendency is for this suspended matter to deposit?—Certainly.

15,385. And Erith Bight is one of those places?—It is.

15,386. Therefore, you would expect to find in Erith Bight a certain proportion of deposit?—What I should expect is that all down the river one would find more or less of the natural deposit of the river mud, whatever it consists of; and I think the samples which have been taken will show that most of the deposits are natural river mud; they are only a question of degree. Where the current is slack, you will find fine stuff like that E.C. sample, which is the deposit from gravel in the upper reaches of the river. Where it is running more freely, as it does at Cubitt Town, you will find it coarser, like the C.T. sample; and in other places, where the current is quicker, you will find it approaches sharp sand and gravel. But in every case you will find the same constituents as you see there, and upon the top, probably, some traces of sewage.

15,387. Now you told us that you put a pole in at Erith about five or six feet down?—Yes, we did.

15,388. And on withdrawing it, did you pass it across the nose?—Yes.

15,389. Was there no smell?—There was nothing but the ordinary riverine smell.

15,390. As far as that went, you would say there was no smell of sewage in the mud?—I could detect nothing.

15,391. As far as the smell of sewage went?—Yes.

15,392. Do you know the channel by Beadel's Wharf?—I do.

15,393. Is that in close proximity to the main outfall sewers?—Yes.

15,394. Would you be surprised if the men who work in that channel come here and complain of the nuisance, having regard to its proximity to the No. 1 outfall sewer at Erith?—No. At the time I was there the No. 1 sewer pipe was broken, and was discharging on the shore at half-tide, but I do not think that would be injurious to health, although it would be unpleasant.

15,395. Now, was there an easterly wind blowing when you put in the floats?—Yes, there was.

15,396. The tendency of an easterly wind would be to make the float set in towards Erith?—That wind would have an effect upon the water, but not upon the floats. The float followed in the stream of the sewage as plainly as possible.

15,397. Did you not tell us that one float was put in near the Crossness sewage outfall?—I have already stated that we lost it in the line of mid-channel.

*Mr. Lumley Smith* stated that there had been no cross-examination upon this point.

Examined by the COMMISSION.

15,398. (*Colonel Ewart.*) I think you mentioned that you had prepared a project for the drainage of Erith?—I have, certainly.

15,399. Where did you propose to discharge the sewage?—I was proposing to deodorise the sewage, and discharge it just above Jenningtree Point.

15,400. Did you propose to deodorise it with chemicals?—Yes, by the lime process.

15,401. Why did you propose to use the chemical process?—In order to comply with the Act of Parliament.

15,402. You proposed to deodorize the sewage before it went into the river?—It was evidently desirable.

The witness withdrew.

Mr. ROBERT GORDON TATHAM called in; examined by Mr. MICHAEL.



15,403. You are a member of the Royal College of Surgeons of England, and a licentiate of Apothecaries Hall?—I am.

15,404. I believe you have been, for over 20 years, surgeon to the Honourable Trinity Corporation?—I have been so for a considerably longer time than that, for I was in partnership with my father some years before that.

15,405. Have you had considerable experience of the river?—I have lived near it all my life.

15,406. Where do you reside now?—At Poplar.

15,407. Has the Trinity Corporation a wharf at Bow Creek, where the River Lea joins the Thames?—Yes, they have.

15,408. I think the wharf is at the actual junction, and faces eastward upon the Lea, and southward upon the Thames?—Yes.

15,409. How are the Trinity men of this district employed?—They are employed on board the light-vessels, at lighthouses in the London district, and on board the steamers.

15,410. At night where are they?—There is a crew that belongs to each vessel, and of those men; a portion of them are down on board for two months, and up at the wharf for one month; each month they are relieved. They sleep at home.

15,411. May I say that all day long they are more or less upon the river?—Those that are at the wharf are down there all day.

15,412. And the other portion, where are they?—They are out at sea.

15,413. Where do they sleep at night?—About in the neighbourhood, in their own houses; they live about in the neighbourhood of Poplar and Blackwall.

15,414. We have adopted the term "riverine" here; may their residences be said to be riverine, or somewhere in contiguity to the river?—I daresay the majority of them live within half a mile of the river.

15,415. How many men are so employed?—There are about 200 who are there; it does not come under me, because I only attend them medically, but I suppose there must be about half of them at the wharf at one time.

15,416. (*Chairman.*) Do you attend the families as well?—Yes, I do attend a good many of them; not on account of the Trinity Corporation, but in general practice.

15,417. (*Mr. Michael.*) What is the health, generally, of the men employed?—They have very good average health.

15,418. Have you been able to attribute any illness that they have had to any emanation from the river?—I have not.

15,419. Have zymotic diseases generally prevailed amongst them?—No.

15,420. (*Chairman.*) Have they ever suffered at all from zymotic diseases?—No, I do not know that they have.

15,421. (*Mr. Michael.*) Could you mention one case of scarlet fever which occurred in a man's family?—That was the Superintendent's family, who live on the wharf.

15,422. Were you able to trace the outbreak in that case of scarlet fever in the family?—The predisposing cause was the defective drainage of the house itself.

15,423. That house has been since rebuilt, has it not?—Yes, they have pulled down the old house, and built another.

15,424. (*Chairman.*) Did you satisfy yourself, personally, that that was the case, that it was owing to the defective drainage of the house?—Yes, perfectly. None of the men on the wharf were ill. The children were going to school, and perhaps they took the disease at school, but they were predisposed to it by the bad state of the drains of the house in which they lived. I examined the house, and reported on it to the Corporation.

15,425. (*Mr. Michael.*) Is there a hulk stationed off the wharf?—Yes.

15,426. How many men sleep there?—Two men.

15,427. Have you had any zymotic disease there?—No.

15,428. (*Chairman.*) Are they always the same men, or do they change?—They are always the same.

15,429. (*Mr. Michael.*) I suppose there could not be any case of zymotic disease among your men without your knowing it?—No, because I attend them all.

15,430. Are there any Trinity steamers lying off the wharf?—Yes, there are constantly.

15,431. And are the men going constantly in boats to and from the steamers?—Yes, they all belong to the same service, so they all are called Trinity men.

15,432. Have you heard any complaints for the last two or three years of the bad state of the river?—Not for the last two or three years; but two or three years ago they used to complain sometimes.

15,433. At that time was there any increase of sickness?—No.

15,434. (*Chairman.*) Did you consider at the time that the complaints were well founded?—Sometimes in the hot weather I have noticed it, but I have not noticed it for the last two or three years.

15,435. (*Professor Williamson.*) What have you noticed?—I have noticed a little bad smell from the river.

15,436. (*Mr. Michael.*) Would that be upon the river itself?—It would be upon the river itself or upon the bank of the river.

15,437. Do you go much upon the river yourself for any purpose?—Occasionally I do.

15,438. (*Dr. Stevenson.*) At what part of the river would you perceive the smell?—It would be down towards Blackwall.

15,439. (*Mr. Michael.*) I think you are also surgeon, are you not, to the East and West India Dock Company?—I am.

15,440. Have you under your charge the men employed upon those docks?—The permanent labourers, foremen, &c.; all those who are residing in my district.

*Mr. R. G. Tatham.*

13 June 1883.

15,441. To what number?—Between 700 and 800.

15,442. Is the water from the river let into those docks every tide?—The gates are opened at every tide.

15,443. And are the men constantly employed more or less on the water or by the side of the water?—Yes, they work all round the dock, from eight in the morning until, on the average, I suppose about five o'clock; sometimes they leave earlier and sometimes later; many of them are employed all night at the tide time.

15,444. Has there been any prevalence of zymotic disease amongst those men?—No, there has not.

15,445. I understand you to say in your proof that there have been 31 deaths in the six years; were any of those from zymotic diseases?—Not one of them.

15,446. (*Chairman.*) Speaking broadly, what number of men is, on the average, employed daily upon the Trinity Wharf?—I have hardly any means of judging of that.

15,447. Do you know how many sleep there; you told us the superintendent did?—The superintendent and his family, and the storekeeper and his family; his family are grown up.

15,448. (*Dr. Stevenson.*) If any cases occurred of zymotic diseases among those men would you be likely to meet with them, or would they be removed to a hospital without your knowledge?—No, they would not be removed to a hospital unless I ordered them to go.

15,449. (*Professor Williamson.*) Then would you kindly explain something that was stated just now. Am I correct in understanding that 31 deaths in six years took place among the 200 men, the average number employed?—No, the average number employed is between 700 and 800 in the dock belonging to the Provident Society.

15,450. (*Mr. Michael.*) I was speaking then of the men employed in the East and West India Docks; were there 31 deaths in six years amongst 700 and 800 men?—Yes; that is an average of $5\frac{1}{6}$th per annum; but no doubt there would be two or three more deaths, because there would be some accidents which would be taken to the hospital and the men would die in hospital; but those 31 would come under my charge.

15,451. I presume any case of disease, putting accidents out of the category, would come under your knowledge; you would be sent for as the surgeon in attendance?—Yes; a few of the men might perhaps belong to a club and go somewhere else, but very few of them.

15,452. Do you reside yourself anywhere near the river?—Yes, I do, and I have done so all my life.

15,453. You do not seem to have suffered very much from any bad emanation of the river if I may judge from your appearance?—No. I was born close by where I am now, and have lived there all my life.

15,454. (*Chairman.*) And about how far from the river as the crow flies?—About a quarter of a mile.

15,455. (*Mr. Michael.*) Have you made any observation of the condition of the mud at the side of the river?—Yes, I have.

15,456. What has been the condition of it in your experience for the last few years; has it increased, or has there been denudation?—There has been denudation. When I first remember it as a boy, all round the Isle of Dogs and opposite at East Greenwich, all along the shore it used to be mud with reeds and rushes growing the same as in country rivers; but since the introduction of small tugs principally, the mud has gradually washed away, until now in most parts it is washed clean to the gravel.

15,457. (*Chairman.*) You attribute that change to the agitation caused by the tug steamers, do you?—Yes, I do.

15,458. (*Mr. Michael.*) Do you think that in consequence of that there has been any increase of matter in suspension in the water?—Yes, most certainly; but the river has cleared itself very much in the last two or three years; that is to say, the water is much clearer now than it was two or three years ago.

15,459. As a general result, may I say that the denudation has swept away the mud and left clean gravel in its place, and that the condition of the water itself in your experience has improved?—Yes, it has; and I have heard the same remark from others about the water-side.

15,460. (*Dr. Stevenson.*) Can you account for that clearing of the river in the last two or three years?—A few years ago, when the tugs came into use, the mud was much mixed with sewage deposited by the tide, and when the denudation began, and until it was washed away, the smell was very bad. Now, however, it is principally earth in suspension, and does not smell as it did before.

Cross-examined by Mr. Lumley Smith.

15,461. These Trinity men are men who are employed some of them in lighthouses, are they not?—Yes.

15,462. And some of them in going out and looking after the buoys and other lights at sea?—Yes, that is all their duty.

15,463. A man is two months in a light-ship at sea, and the other month he comes back and stays at home?—Yes.

15,464. Two months is as much as a man can stand in a lighthouse, so he comes and stays a month at home?—No, the lighthouse keepers are men who are changed every month.

15,465. But the greater part of the time the men of the light-ships are in good fresh air at sea?—Yes, they are.

15,466. And during the time they are not at work, they are hanging about the wharf?—Yes, that is so.

15,467. Have they anything to do, or is it merely staying at their homes, or have they to report themselves at the wharf?—They are down at the wharf the whole day.

15,468. (*Chairman.*) There is duty ashore and duty afloat to give the men the necessary amount of change?—Yes, exactly.

15,469. (*Mr. Lumley Smith.*) What have they to do at the wharf?—They have to send stores from there all round the coast, to keep the vessels supplied with oil, and all sorts of things; and, moreover, frequently some of the men have to go away in steamers.

15,470. They are men in good health ordinarily, are they not?—They have to come to me to be examined before they are taken on in the service.

15,471. They are not taken into the service before you have certified that they are fit for the service?—They are not.

15,472. And they are men who spend two-thirds of their time in good fresh air out at sea?—Yes, they are.

15,473. And then, in case of illness, do you attend the men at their homes?—Yes, I do.

15,474. Are they men who belong to clubs at all?—No doubt some of them do.

15,475. And among the labourers a good many belong to clubs, do they not; that is to say, among the East and West India Dock labourers?—They have a club belonging to the dock itself, a provident society, and they all belong to that; the whole of these men that I speak of belong to that society.

15,476. Have they any medical attendant attached to that club?—Yes, I am the medical attendant of the club.

15,477. The labourers, I suppose, are strong active

men?—Yes, and they have to come to me to be examined.

15,478. They have to come to you to be examined and certified before they are taken on?—Yes.

15,479. Now, with regard to the illness that does take place, do you keep any record of it, or are you speaking from memory as to the cases of illness?—I make no report, but I put down in my diary when the men apply to me what the diseases are that they are suffering from.

15,480. But the exact catalogue of all the diseases that you have attended would take a long time to make out, would it not?—Yes, it would.

15,481. Now you spoke of rushes having been seen upon the banks of the Thames; what period were you speaking of then?—That would be a long time ago. I was speaking of 40 years ago.

15,482. And they have disappeared, have they not?—Entirely.

15,483. Did they go before the mud; because what I was going to suggest to you was that the river was very bad in the neighbourhood of Blackwall?—Yes.

15,484. We have heard that sewage destroys vegetation sometimes; may it not have been that the sewage was so bad in the London neighbourhood and extending to Blackwall that it destroyed the rushes?—I could give no opinion upon that, but I can say that down to 1849 up the River Lea there were reeds and rushes growing, because I remember when I was a student at the time I went botanising along there, and I went along the banks of the Lea, and I took home 50 specimens of plants growing upon the banks of the Lea.

*Mr. R. G. Tatham.*

13 June 1883.

15,485. (*Chairman.*) Within what distance from the Thames?—Just a little above this Trinity Wharf.

15,486. You do not mean far up the Lea, but in the immediate neighbourhood of the Thames?—In the immediate neighbourhood of the Thames.

15,487. (*Mr. Lumley Smith.*) Do you say you could perceive the sewage in the river as far down as the Lea, before the outfalls were open?—No, I did not say that.

15,488. You have been asked about the state of the river and the reeds before the outfalls were opened?—I would rather not give an opinion as to what caused the death of the plants.

15,489. But I will ask you, was the river bad from the London sewage before the outfalls were opened; am I right in my assumption?—Yes, I think so.

15,490. You think that at that point you could perceive the effect of London sewage?—I have noticed it in crossing in steamers to Greenwich.

Cross-examined by Mr. Beaumont Morice.

15,491. I will ask you one question about the mud; have you noticed whether the mud near the entrance to the docks has increased in the last few years?—That I could hardly say; it would be more by dredging that they would find that out.

15,492. As a fact you have not noticed it?—No. I have noticed more what is to be seen between high and low tides.

15,493. Has there been any alteration in the quantity or quality of the mud?—The mud has been washed away down to the gravel, leaving many places clear, where, when I was a boy, it was mud up to the knees for aught I know, but where you could now walk along as you could upon the beach by the sea-side.

15,494. Do you find any smell from the mud that there is there?—I do not notice any smell, and I have not heard any complaints lately from the men. About two or three years ago there was a good deal of complaint; the men noticed it very much at the time of letting the water out of the dock when it stirred up the mud that was in the lock; but since then I have not found it so. I have heard the dock officials say the same thing.

15,495. We have it in evidence from Captain Hussey, who was the principal dock-master at the docks, that he finds what he calls a great stench; do you notice anything of the kind from the mud?—I have not noticed it, but that would be at the time I mention. Those locks are enclosed with gates at each end, and if they want to make a level they would open the sluices and the water would come through and stir up the mud; and it is quite likely that at some time of the tide they would smell it if they were on the spot, whereas I might go down an hour afterwards and not notice it.

15,496. (*Colonel Ewart.*) I should like to ask you about the men working near the river?—To which of the two classes of men I attend are you referring?

15,497. To all of them; do they go to work before sunrise?—No, they do not go to work so early as that.

15,498. Do they go shortly after sunrise?—Yes.

15,499. And they leave before or at sunset?—Yes, they work from eight o'clock in the morning in the summer and from nine in the winter to what is supposed to be four in the afternoon, but it is frequently, as likely as not, six o'clock before they get away. Now they work at such high pressure that they frequently work at night.

15,500. In point of fact, between sunset and sunrise the men are living away from the river, are they not?—Yes, excepting the gate-men who attend at the gates taking in the vessels; they attend there every tide, whether it is night or day; they are down there for about four hours each tide.

Re-examined by Mr. Michael.

15,501. Could you tell the Commission about the distance, on an average, those men live and sleep from the river?—The distance within which I attend them would be within at any rate two miles of the river; they are scattered about.

15,502. (*Chairman.*) Do they live as far as two miles back inland from the river?—Some of them will live nearly over by Victoria Park, but the majority of them live within about half a mile of the river.

15,503. (*Mr. Michael.*) Are you also in general practice in the district attending persons living close to the river?—I am.

15,504. Are you able to say whether zymotic diseases prevail more largely close to the river than at a distance from it?—The people are very healthy about Poplar.

The witness withdrew.

Dr. Walter Dickson called in; examined by Mr. Michael.

15,505. You are a doctor of medicine of the Royal Navy, and have been for the last 21 years Medical Inspector of Her Majesty's Customs?—I have.

15,506. I believe among the duties appertaining to your office is that of supervising the health of the subaltern custom-house officers of the Port of London?—It is.

15,507. They consist of about 1,000 persons?—Yes, they have averaged about that number.

*Dr. W. Dickson.*

15,508. How long are those officers occupied in the day?—The time varies; those who are employed on day duty are at work from 8 to 12 hours, but many have night duty as well, and Sunday duty. For example, ships arriving off Gravesend are boarded by

*Dr. W. Dickson.*

13 June 1883.

officers at Gravesend, who board the ship and remain on board for the protection of the revenue until all the cargo is discharged, and those men spend all their time, day and night, on board the ships, except for a day or two occasionally, when they go to their homes at Gravesend.

15,509. Do you think that the night duty may be said to be entirely upon the river?—Yes; and those men on night duty would number about 500 men out of the whole number.

15,510. Are all those men employed upon the river, either day or night?—No, not altogether at the same time.

15,511. What proportion of them would be?—If you include the wharves and the docks, I should say three-fourths of the whole number of customs officers are employed on or upon the margin of the river.

15,512. (*Chairman.*) What did you say was the average number employed upon the river all the year through, taking day and night?—I should say not less than 500, or certainly not less than 400, actually on the river at one time.

15,513. (*Mr. Michael.*) Have you a section of your men who live almost constantly upon the river called the watermen?—Yes, they are very much upon the river; they are employed in what is called "rummaging." When a vessel comes in from abroad, they go and search her, down the holds and underneath the boilers, in quest of tobacco, which is usually the object of their search; and they are exposed to great changes of temperature; and, moreover, the commercial pressure is such, owing to the anxiety to get the cargoes discharged as quickly as possible, that they are employed at all hours for the purpose of rummaging.

15,514. All those men have very laborious duties to perform, and are much exposed to the weather?—Yes, they are.

15,515. A considerable number of them are constantly on the river itself, day and night?—Yes, they are.

15,516. Are you able to say what the health of the men is?—Considering the nature of their duties, I look upon it as remarkably good; the per-centage of the sick is about 3½ to 4 per cent. I have gone into the statistics very minutely for about 21 years, and that is the proportion; it is very rare that more than 3 or 4 per cent. are disabled from their duty, either by disease or accident.

15,517. (*Chairman.*) But we have nothing to do with accident here, so you must eliminate those?—You might say 3½ per cent. then as the average number of the sick.

15,518. (*Mr. Michael.*) Can you say whether zymotic diseases prevail amongst them?—They are exceedingly rare; they are almost unknown.

15,519. I see you have had only two fatal cases of cholera recorded within the last 26 years?—Yes.

15,520. And they were sporadic?—Yes, I believe so. One case occurred in 1861, at the time of the great fire at London Bridge, when the man was exposed to great fatigue, and he took the cholera, and died; but, I believe, there was no cholera in or near England at that time. The next case was in the year 1866, when cholera was epidemic in London, and when, although we had no cholera in the Customs force, we had a great deal of choleraic diarrhœa; but the case of the man who died was a case evidently self-induced. He was in perfect health, and, like many people, wishing to be better, took a couple of Cockle's pills, which brought on profuse purging, which became cholera, and he died of the consecutive fever in a few days.

15,521. Do a large number of your men live at Gravesend?—About 250.

15,522. Are you able to tell the Commission what is the health of the men?—It is very good, even better than the health of the men in London.

15,523. I think you have weekly returns, have you not, of the health of all your men forwarded to you?—Yes, I have.

15,524. You, in fact, have the general superintendence of the sanitary condition of the whole of your men?—Yes.

15,525. Would you give your opinion to the Commission as to the general state of health with respect to zymotic diseases of all the men under your charge, or whom you take cognizance of?—It is very good; singularly good.

15,526. Have you been able to trace, in any single instance, any case of zymotic disease originating or caused by the condition of the river?—No case.

15,527. Could such cases occur amongst your men without its being brought under your cognizance?—It would be impossible; they cannot be withdrawn from duty without my knowing it; they have every encouragement to apply; they suffer no stoppage of their pay for six months; they are treated most liberally; so that no case of illness could occur without my knowing it.

15,528. (*Chairman.*) Are the men attended free of charge by yourself?—Yes, and they are also supplied with medicine.

15,529. (*Mr. Michael.*) I think Dr. McWilliam was your predecessor?—Yes, he was.

15,530. He speaks of the very bad condition of the river antecedent to the opening of the sewage outfalls?—He does.

15,531. Are you yourself much upon the river?—Not at present. I was some years ago. I made use of boats to cross to Bermondsey and Rotherhithe, but it has become so very dangerous to go across in boats, on account of the steamers, that I have abandoned it, and go round by London Bridge or by the East London Railway.

15,532. (*Chairman.*) Where do you live?—I used to reside on Tower Hill; now I live in the suburbs: but my office is upon the Custom House Quay where I am occupied usually four or five hours a day.

15,533. (*Chairman.*) Have you any considerable number of your men residing at the Custom House; or can you name any particular point upon the river where a number of the men of the Customs are concentrated?—No, they are widely scattered in the suburbs.

15,534. Gravesend is the only point upon the river where the men that are employed in that department are concentrated?—Yes, it is.

15,535. (*Mr. Michael.*) Have you ever had it brought to your notice, as medical superintendent, that disease has resulted from the condition of the river?—No, I have never known any case of that kind either in my own experience or in the experience of others.

15,536. (*Dr. Stevenson.*) In the years 1858 and 1859 that you have spoken of, do you know whether disease was prevalent upon the river?—I do not know the circumstances except from Dr. McWilliam's reports. He says that diarrhœa was not more prevalent then than in any other year; but an extract from his report is to be read, I believe, before the Commission.

15,537. (*Chairman.*) Have you observed the condition of the river water from time to time during your term of office?—Do you mean with regard to offensive smells?

15,537a. Yes?—Occasionally I have perceived such smells, but very rarely.

15,538. One would expect that you had from your official position noticed the state of the water?—Yes: occasionally, when the tide is low, as there is a mud bank in front of Custom House Quay, there has been in hot weather a little smell; occasionally in other parts of the river I have observed an unpleasant smell in hot weather, when the mud has been stirred up by the steamers, but not lately.

15,539. Comparing the last 10 years of your period of office with the first 10 years, what would you say was the relative condition of the river during those two periods?—I should say it is much improved.

15,540. That is to say, as to smell?—Yes, as to smell.

15,541. And as to appearance?—Yes.

15,542. (*Dr. Stevenson.*) What part of the river do you include in your remarks?—I seldom go further down than the East India Docks.

15,543. (*Chairman.*) I gather that you have no intimate acquaintance with the part of the river at the two outfalls?—I have never been there; our officers board the ships at Gravesend, and my duties do not call me farther.

15,544. Then, when you go to Gravesend, do you go by water?—No, I generally go by train.

15,545. But you would be familiar with complaints if there were any?—I certainly should have heard complaints made if there had been any to make. I have asked the officers sometimes, and they tell me there is no great nuisance of that kind experienced on board the ships.

*Dr. W. Dickson.*

13 June 1883.

Cross-examined by Mr. Lumley Smith.

15,546. Are the Custom House officers examined medically before they are taken into the service; are they certified to be strong healthy men?—Yes, they are.

15,547. When did you start your term of office?—In 1862.

15,548. My learned friend, Mr. Michael, asked you about the report of Dr. McWilliam; would you kindly refer me to it?

(*The same was handed to the learned Counsel.*)

15,549. Does this refer to the part below the outfalls?—No, to the whole river. I find that such smells as we now suffer from at the Custom House are due to the Billingsgate Market.

15,550. I find in this report, "It was at this time that the river," that is, in June 1859, "that the river "and the docks began to smell most offensively, and "serious apprehensions for the public health were "entertained. Some of the men complained of "nausea, and occasionally of headache,—symptoms "which they ascribed to the foul state of the river; "but although there were a few cases of diarrhœa of "sufficient severity to cause temporary absence from "duty, that disorder certainly was less rife than "during the previous year, when the odour from "the river was also noisome in smell, but by no "means to the same extent as during the hot months "of the past year." "Notwithstanding the dock "and river effluvia evolved by the action of high "temperature, the waterside department also continued "healthy, and to a degree almost unprecedented in "the service, 35 officers only in 529 strength having "been placed on the sick list during the quarter." That is the extract you are speaking of, is it not?—Yes; there may be others even stronger.

15,551. Then I find "Third quarter, the health "standard of both departments was high during this "quarter, and that of the general population was also "above the average, although diarrhœa prevailed to a "considerable extent in some of the districts of "London. The temperature of the air in July was "below, in August slightly above, and in September "as much as four degrees above the average. The "rainfall was below the average. The foul state of "the river still continued to excite some apprehension "of danger to the public health; but in the water-"guard and waterside departments, as I shall hereafter "endeavour to show, there was less of bowel affections "than there had been at the corresponding period of "any year since the cholera epidemic years. There "was no case of death in either department during "the quarter." He seems to have thought that the bad state of the river might be bad for the health?—But it turned out not to be so as far as regards bowel complaints.

15,552-3. Have you any reports that you have made since you have been there?—Yes, I have reports very nearly of the same character, going minutely into the effect of seasons, &c. upon the health of the men; the cold winter is our most injurious factor of disease.

(*Chairman.*) Have those any material bearing upon our inquiry. They seem to show that injury to health was apprehended.

(*Mr. Michael.*) And did not take place.

*Mr. Beaumont Morice* stated that he had no questions to ask the witness in cross-examination.

The witness withdrew.

Mr. William Joseph Dibdin called in; examined by Mr. Michael.

15,554. I believe you are a Fellow of the Institute of Chemistry and a Fellow of the Chemical Society?—I am.

15,555. Were you assistant to the late Mr. Keates, the Consulting Chemist to the Metropolitan Board of Works?—I was.

15,556. For how long were you his assistant?—For about five years.

15,557. And since his death, I believe you have been Chemical Assistant to the Metropolitan Board of Works?—I have.

15,558. I believe that you have personally made all the analyses in a book which I am about to put in?—I have.

15,559. And you have also made a considerable number of analyses in a book to be put in subsequently by Dr. Dupré?—That is so.

15,560. You have made, have you not, a series of investigations as to the condition of the river?—Yes.

15,561. And especially with respect to the effect produced upon the river water by the sewage which is introduced into it?—From the Metropolitan Board's outfalls, yes.

15,562. In 1878 there were two series of investigations carried out under the direction of Mr. Keates, and a great many analyses were made by you for him?—Yes, those are the analyses made in reply to the report by Captain Calver.

15,563. Then in 1880 did you make another series of analyses?—In 1878, beginning in January, February, and March, the first series was made, and then later on, in October and November, a second investigation was made in consequence of the accident to the "Princess Alice," and in 1880 the investigations were renewed.

*Mr. W. J. Dibdin.*

15,564. What was the main object you had in view in making those analyses?—To ascertain the character of the river water, as to whether it was impregnated with sewage to such an extent as to be injurious to the health of those travelling upon the river or living in the neighbourhood.

15,565. What process have you mainly adopted?—The process which has been particularly adopted in the analyses I have carried out to ascertain the quantity of sewage is that which is known as Wanklyn's ammonia process, that is a process which gives an index to the amount of nitrogenous organic matter present in the water.

15,566. I believe this is a delicate and trustworthy mode of ascertaining the amount of impurity present in the water?—Decidedly.

15,567. (*Chairman.*) Is it the best you know?—It is.

15,568. And is it so recognised?—It is; it is the one recognised and adopted by Professor Way in the analyses he has put in, and in the experiments he has described, and it is one which I am satisfied is a reliable process. It is not one which gives the absolute amount of organic matter, but it gives the relative amount.

15,569. (*Mr. Michael.*) Having adopted it for

*Mr. W. J. Dibdin.*

13 June 1883.

your purposes, are you able to bring before the Commission the comparative purity of those waters which you have examined, and which are set forth in your table?—I am.

15,570. To commence with, you took the sewage itself, did you not, as delivered both at the northern and at the southern outfalls?—Yes. A series of samples was collected from the sewers as the sewage was running into the reservoirs, so that we might have the sewage pure and simple, and independent of the river water; because when it gets into the reservoir a sort of settling down takes place, whereas we wanted to get a fair average of the actual sewage.

15,571. (*Chairman.*) You are speaking of the sewers at the outfalls, are you not?—Yes, at the outfalls.

15,572. (*Mr. Michael.*) Did you determine from the sewage itself as it entered the reservoir, taking that as a fair test, what quantity of organic ammonia was to be found in the sewage?—I have here a series of analyses which has been made of the sewages. I am sorry to say the copy has not come from the press, I have only a proof at present. I was in hopes that the tables would have been ready for my evidence this afternoon, and I may say we expect them immediately, and as soon as they arrive we will put them in.

15,573. What is the quantity of ammonia per gallon in the London sewage? — Of albuminoid ammonia the average quantity in the series of samples I have examined is equal to ·366 of a grain per gallon.

15,574. That is rather more than one third of a grain per gallon, is it not?—Yes; there are some samples which contain a considerably higher quantity and others a less quantity.

15,575. How many analyses have you made in order to arrive at your average of ·366 of a grain of albuminoid ammonia in a gallon of sewage?—One hundred and eighty-one samples, which were collected at intervals of four hours from each outfall.

15,576. (*Chairman.*) Were the samples taken at regular intervals of four hours over the whole 24?—Over the whole 24.

15,577. (*Mr. Lumley Smith.*) Are the north and south samples mixed?—No, they are separate.

15,578. (*Mr. Michael.*) The details of those analyses you will put in to the Commission as soon as they arrive?—I will. (*See Appendices* BX *and* BY).

15,579. In order to find the quantity of albuminoid ammonia in water to compare with sewage, what kind of water did you take to furnish you with the means of comparison?—The ordinary Thames filtered water as supplied by the London water companies; and upon that I found from a number of analyses that the albuminoid ammonia which is in the sewage is ·366, whereas in the filtered water it is ·005 or $\frac{5}{1000}$ths of a grain per gallon.

15,580. You adopted the same method of analysis in the two cases?—Yes; exactly the same conditions were adhered to in the analysis of each, so that the results in either case might be strictly comparative.

15,581. Having ascertained those two points of comparison, what did you do subsequently?—We examined a number of samples from the river. Samples from the river have been examined at different periods down to the present time. This particular series of sewages I am mentioning were carried out through the months of March, April, and May of the present year.

15,582. (*Dr. Stevenson.*) The samples were not taken at four hour intervals consecutively, were they?—The sewages were taken consecutively in the month of March, on the 23rd, 24th, and 25th; they were taken through the months of March, April, and a portion of May, so that not a single day was missed during the period of collection, with the exception of one or two Sundays, at the northern outfall.

15,583. (*Mr. Michael.*) Otherwise, it was a consecutive series of four hours samples?—Yes.

15,584. (*Dr. Stevenson.*) What were the hours at which they were taken?—They commenced taking them at the Southern outfall at 6 and 10 a.m., and 2 p.m., 6 p.m., and so on every four hours. I then gave instructions that those hours should be varied, and they commenced taking them at hours varied so as to follow the tides; as the tides varied so they varied; so that we have the times at which the samples were taken in the day, varied at intervals about 40 minutes later each day.

15,585. (*Mr. Michael.*) Was that with the object, if there is any variation in the quality of the sewage from time to time, that you should exhaust the whole of the possibilities so as to get an absolute average of the quantity of putrescible matter in the sewage itself?—That is so; every care was taken that the results of those analyses should give a fair indication of the character of ordinary London sewage.

15,586. Do you think you have really got now an absolute standard to go upon of the quantity of putrescible matter in the London sewage as discharged at the two outfalls?—I believe so.

15,587. Having got those two sets, how did you proceed in order to determine the effect upon the river water of the projection of the sewage into it at the outfalls?—Samples have been examined at different times of the sewage as it was discharging into the river water, and samples of the water have been collected outside, that is to say, upon the river side, of the line of junction of the sewage and river water.

(*Chairman.*) Those of the Commission who went down saw very clearly the line of demarcation between the sewage and the river water.

(*Witness.*) I shall be able to show you very clearly the difference.

15,588. (*Mr. Michael.*) You say that there is a clear line of demarcation to be observed in the river where the sewage is for the first time allowed to get into the river itself—you can see where the sewage is, and you can see on both sides where practically the sewage is not?—That is so.

15,589. And in order to make it perfectly clear to the Commission, you have taken samples, have you not, first in the line of the sewage itself, and secondly on both sides of it?—Yes, that is so.

15,590. Will you explain in your own way what the steps were that you have taken, and how many analyses, and so on, in order to arrive at a determination of what quantity of putrescible matter was to be found in the sewage in the river at various points and at various states of the tide? — Perhaps the Commission will kindly turn to Diagram No. 1, at the end of the series of tables, which shows the "quantity of albuminoid ammonia yielded by samples "collected on shore side and mid-stream side of line "of junction of sewage and river water at the "northern outfall, while sewage was discharging" on October 15th, 1878, which is represented by the blue line, and August 11th, 1880, which is represented by the red line. The actual figures of the analyses are given on page 11, Nos. 203 to 206.

15,591. Is this diagram drawn to scale?—Yes, the scale is given at the side; 1 inch in height represents one-tenth of a grain per gallon. The amount of albuminoid ammonia on the shore side of the line of junction in the sample collected on October 15th, 1878, is shown to be ·254, while in the mid-stream side, the short blue line, it is ·067. On August 11th, 1880, a sample collected on the shore side of the line of junction of sewage and river water was ·207 and upon the mid-stream side it was ·027. The sample collected on August 11th, 1880, was collected from a boat which was placed at right angles to the stream; the sample of the sewage being taken at one end of the boat, and the sample of the river water being taken at the other end of the boat,—so that the samples were taken very close together.

15,592. (*Professor Williamson.*) Was the boat drifting with the current? — It might have been drifting with the current.

15,593. (*Mr. Lumley Smith.*) The two samples, you say, were taken, one at each end of the boat?—

One sample was taken at each end of the boat, the first sample being in the sewage, the second being in the river water.

15,594. (*Mr. Michael.*) The line of demarcation enabling you to make a distinction between them?—Yes, that being about midships.

15,595. (*Chairman.*) Is there any reason why these two particular dates were selected?—They happen to be samples taken at different times; they were taken with the view of showing this fact that the line of demarcation is very sharp indeed.

15,596. But my question has reference to those particular dates?—No, I think there was no special reason for the selection.

15,597. (*Prof. Williamson.*) The line of demarcation is very sharp near the outfall, I presume not anywhere else?—Yes, those are taken at 200 feet and 600 feet from the northern outfall, and on one occasion on the north side they were taken when there had been an overflow of an hour, and a second sample was taken at nearly the same position as the last, but 12 feet from and on the mid-stream side of the line of direction of sewage and river water, so that those two samples which were both taken upon the 11th August, 1880, were only 24 feet apart.

15,598. (*Mr. Michael.*) The sample taken upon October 15th, 1878, was taken in consequence of the "Princess Alice" disaster, was it not?—Yes.

15,599. That was about six weeks after the accident, I think; the accident was upon the 3rd September?—Yes, it was. Complaints were made at the time of the state of the river, as the Commission are well aware, and the Board ordered the analysis to be made.

15,600. Now, having explained diagram No. 1, will you come to No. 2, and tell the Commission what that is intended to represent?—No. 2 shows diagramatically the analyses which are given in table No. 5 upon the same page, No. 207 to 225. The Commission will see that there are four series of samples collected in the line of sewage flowing from the northern outfall.

15,601. What is the object of the diagram?—The object of the diagram is to show the decrease in the quantity of albuminoid ammonia yielded by samples collected in the line of sewage flow from the northern outfall on October 15th, 1878, as represented by the red line; on March 13th, 1882, as represented by the red dotted line; on August 11th, 1882, at the surface, as represented by the blue line, and upon the same date at three feet above the bed of the river, as represented by the blue dotted line. On October 15th, 1878, it will be seen that the quantity of albuminoid ammonia yielded by a sample collected off the outfall in the sewage showed albuminoid ammonia equal to ·254. A sample taken at Barking Creek yielded ·186. But it will be seen that following the red line of October 15th, 1878, it decreases at False Point.

15,602. (*Chairman.*) This is the first time we have heard of False Point, will you tell us where it is?—It is below the Barking Guano Works.

15,603. (*Mr. Michael.*) Will you tell the Commission, if you please, what time elapsed between your taking those various samples?—The first sample opposite the northern outfall was taken at 3.50 p.m., the second sample in the course of the sewage at Barking Creek was taken at 4.5 p.m. Then the collector went further down, collecting samples off False Point, and then between the two powder magazines, and again off Crossness Point, by which time, when he arrived at Crossness Point, it was 5 p.m., so that the sample off False Point and the one between the two powder magazines must have been taken at some period of time between 4.5 and 5 o'clock, the boat rowing from point to point, the interval of 55 minutes being occupied in taking samples and moving from place to place.

15,604. May I take it generally as the result of your observations that you have found any considerable difference between the condition of the water at the surface and some distance below?—No, there is practically no difference between the water at the surface and the water just above the bed of the river. You will find that the diffusion of the sewage and river water is complete, there is very little difference between the samples. But dealing with the sewage from the outfalls, following it down the river, the mixture of the sewage with the river water is very complete indeed.

15,605. (*Mr. Lumley Smith.*) Is it the same all the way down, do I understand, from the surface to the bottom?—If you look at diagram No. 2, the blue dotted line shows the amount of albuminoid ammonia yielded by samples collected on August 11th, 1882, at the surface and three feet from the bottom.

15,606. (*Chairman.*) But supposing the water were 40 feet deep there, what would it be at 30 feet from the surface. I understood you just now to say that the composition was very nearly uniform from the surface to the bottom?—Yes.

15,607. That is your general conclusion derived from a number of observations?—Yes.

15,608. (*Mr. Michael.*) How do you find it with respect to the suspended matter, is there any difference?—With respect to the suspended matter, there is no doubt that some of the heavy particles of the suspended matter, the sand, and so on, would have a tendency to settle to the bottom of the river, but the suspended matter in the sewage is very much lighter, about half the gravity of the river suspended matter.

15,609. Then that uniformity you referred to just now refers to the solubility of the albuminoid ammonia?—Yes. I should have mentioned that in all the samples given here the suspended matter has been allowed to settle in the bottle in which the sample was taken, and the clear water taken for the purpose of examination, the suspended matter having in many cases been examined separately.

15,610. (*Prof. Williamson.*) Is there a uniformity with regard to the chlorine corresponding to that which you have mentioned in regard to the albuminoid ammonia?—In Table No. 5, samples 207 to 211, on October 15th, 1878 (which are a series from the Northern Outfall to Crossness Point), show that there is a gradual increase in chlorine from the outfall down the river, because, when the sewage meets with the river water, the quantity of chlorine is less: the more sewage, the less chlorine.

15,611. But at different depths of water you said the proportion of albuminoid ammonia was the same. Now at different depths is the quantity of chlorine the same?—Not precisely, but there is a very close accordance. In the sample at the surface on August 11th, 1882 (*referring to No.* 218), immediately off the outfall the chlorine was only 40 grains, but three feet above the bed of the river the chlorine was 138 grains, that is immediately off the outfall, when the sewage was discharging into a considerable depth of water. But if we follow it down to Lawes' Chemical Works, which are just the other side of Barking Creek, we find that at the surface the chlorine was 361, while three feet above the bed of the river it was 394, showing an excess of 33 grains. Then further down, 200 yards above the Land Powder Magazine, upon the surface the chlorine was 392, and three feet above the bed of the river it was 398, showing that the mixture was still more complete. Whereas, if we go to Crossness Point on the same day, we find a slightly greater difference, the excess of chlorine being still in the bottom of the river: a fact which is always found in examining river water, that the chlorine is always in excess at the bottom, independently of sewage.

15,612. It would seem strange if in any water the albuminoid ammonia were to be perfectly constant at the different depths, and the chlorine to be different; one would think they must go together. If there is a complete mixture, the albuminoid ammonia will be uniform; if there is not a complete mixture, they will be different?—There is not a complete admixture at the outfall, but as you get a few hundred yards down, the quantity of chlorine in the surface and bottom samples is tolerably constant.

*Mr. W. J. Dibdin.*

13 June 1883.

15,613. It was an appreciable difference at Lawes' Works?—At Lawes' Works it was 391 and 394.

15,614. (*Chairman.*) When were the samples taken?—These samples were taken on the ebb.

15,615. (*Prof. Williamson.*) May I ask this question in order to save unnecessary trouble to yourself and to the Commission. What bearing do you conceive that there is between the proportion of albuminoid ammonia in the water and the proportion of sewage, because you know perfectly well that albuminoid ammonia ceases to be albuminoid ammonia in proportion as the material gets decomposed: the nitrogen is there, but no longer combines in that way; so that, if you got a cubic foot of sewage, that cubic foot does not after a while contain as much albuminoid ammonia as it did at first, so that the albuminoid ammonia is not a fixed and permanent mark of sewage. Therefore what interpretation do you put upon these facts regarding the amount of albuminoid ammonia in the river at different places, have they a direct bearing upon the quantity of sewage in it?—Undoubtedly; I think the analysis will show that if we take sewage we get a very considerable quantity of organic ammonia, if we take sewage *plus* river water, we get a very considerable decrease in the albuminoid ammonia in accordance with the degree of dilution; so we may take the quantity of albuminoid ammonia as an index of the quantity of sewage-matter present.

15,616. You mean the quantity of organic matter which is in the sewage?—Precisely.

15,617. If you use the term "sewage" as meaning the quantity that was in it when it flowed out, that is one thing; but if you use it as indicating the amount of organic matter that was in it, that is another thing. The sewage constituents are measured by the albuminoid ammonia, but when they are decomposed the albuminoid ammonia is no longer there as albuminoid ammonia?—No, that is so.

15,618. But the engineers have been speaking of the decomposed liquid as if it were still sewage?—I am speaking of the sewage when it is in such a condition that it yields a certain amount of albuminoid ammonia to analysis. When the character of the sewage is so altered that it no longer yields that quantity of albuminoid ammonia, I speak of it as water.

15,619. When it is liable to be noxious or unpleasant, do you consider the albuminoid ammonia is the measure of it; that it is noxious by reason of the albuminoid ammonia, or when it is decomposed?—The general bearing of these facts is that the albuminoid ammonia is now taken as an index of the amount of putrescible nitrogenous organic matter, and I am speaking of the sewage in regard to the amount of putrescible nitrogenous organic matter.

15,620. When it has putrified then it is noxious?—When it is in a putrid condition I take it we shall still get a certain quantity of albuminoid ammonia.

15,621. As far as it is not decomposed, the ammonia is albuminoid; when it is decomposed it is no longer albuminoid?—When the decomposition is complete we shall no doubt lose the albuminoid character of it.

15,622. (*Mr. Michael.*) Will you explain, in order that the Commission may understand it, the object of your tables. You have taken first, have you not, the quantity of putrescible matter which is found in the sewage; you have taken some pure standard; you have taken, I believe, the water into which the sewage has been poured in order to have some test at first of the quantity of sewage which exists in the water at the moment of leaving the outfall; am I right to that extent?—That is so.

15,623. Then immediately afterwards do you say that any changes do or do not take place in the condition of the sewage as it is poured into the water?—Undoubtedly they do.

15,624. Changes take place, destroying the condition in which it is poured into the water?—Undoubtedly.

15,625. Are you endeavouring by your tables and diagrams to trace these changes, and to show what the condition of the water is quâ the sewage that has been first poured into it?—Yes.

15,626. Is that the object you have in view, whether rightly or wrongly, in putting forward these tables?—Yes.

15,627. (*Professor Williamson.*) But to trace the changes, I consider one would require to know two things. In the first place, the actual number of cubic feet of sewage in particular places mixed with the unit quantity of water, and at the same time the proportion of albuminoid ammonia in each cubic foot of sewage. You would require to have an independent record of the amount of sewage which flows out of the outfalls, and to see whether the albuminoid ammonia remains in the same proportion to that, or whether it varies?—All my results are stated in grains per gallon, so that the quantity of albuminoid ammonia I have found is that which would be yielded by a gallon of water or sewage, or a mixture of water and sewage.

15,628. (*Mr. Michael.*) Have you taken three analyses, first in mid-stream, which may be said to be nearly all sewage, then the sewage on both sides of the stream where the sewage has commenced to mix with the water, and then have you traced subsequently the alterations from the changes which the sewage undergoes?—Yes.

15,629. You regard, as I understand, the quantity of albuminoid ammonia in the matter as a distinct and correct measure of the putrescible matter which is in the sewage?—Yes, of the nitrogenous putrescible matter.

15,630. Another as that falls away, this becomes less and less putrid, not only less putrescible, but less and less putrid?—The quantity of putrescible matter is less, the actual quantity present is less.

15,631. May it not be capable of becoming more and more putrid, although the quantity may be less?—By putrefaction and oxidation there is no doubt it does undergo a very rapid alteration indeed. The object of the analyses and tables is to show that change, that is, the change in the quantity of putrescible nitrogeneous organic matter which is present in a given quantity of that water.

(*Mr. Lumley Smith.*) And not of the non-putrescible?

15,632. (*Mr. Michael.*) That is due to two causes; the first, a very important one, is dilution, being mixed with a very large quantity of water?—Yes.

15,633. And secondly changes occurring of a chemical and physical character, owing to some substances with which it comes in contact in the water itself?—That is so.

15,634. The sum of those two differences you are now giving; the amount attributable to each of those you have not come to?—I have not given that, except that in the sewage there is a certain amount of nitrogenous organic matter which is indicated by the amount of albuminoid ammonia yielded to analysis. In the water there is a less amount, and we find there is a certain quantity in ordinary London drinking water.

15,635. (*Chairman.*) I should like to be clear about it. It is clear that the proportion of putrescible matter is becoming less and less very rapidly. Now there may be a less quantity of putrescible matter, but has it arrived at what I may call its maximum putridity, has it become as putrid as it will ultimately become?—That I think it is impossible to say.

15,636. (*Dr. Stevenson.*) You deal with what is undergoing putrefaction and also with what is capable of becoming putrid?—Yes, the total quantity; it may not at the time be in an offensive condition, but it would become so afterwards.

15,637. (*Chairman.*) You say these samples are collected in the line of sewage flow from the northern outfall?—Yes.

15,638. What we saw when the Commission were down there was that the line of demarcation between the sewage water and the river water was very clear to somewhere about False Point; but below that point, looking to the particular configuration of the river the,

sewage would be distributed over the whole river width?—It is so.

15,639. Then, in fact, that marked sewage flow would apply to False Point and not beyond?—Upon certain occasions you can see it further down.

15,640. (*Mr. Michael.*) Would you point out to the Chairman where you followed it, it is a regularly diminishing shade of difference?—If you turn to No. 210 in mid-channel between the two powder magazines, which is a short distance below False Point, the albuminoid ammonia is reduced to ·061, it is first seen to be ·254, then ·186, then ·063, then ·061, and ·025 off Crossness Point. At No. 209 a note was made by the collector that off False Point the sewage was traced thus far, but that "in mid-channel between two powder magazines no trace of sewage could be seen," and again, "Off Crossness Point no trace of sewage observable."

15,641. (*Chairman.*) Then below False Point the sewage, whatever the quantity of it may be, is pretty fairly distributed over the whole of the river?—That is so.

15,642. (*Mr. Michael.*) Would you begin with diagram No. 3, showing the amount of albuminoid ammonia from the southern outfall?—"Showing the "decrease in the quantity of albuminoid ammonia "yielded by samples collected in the line of sewage "flow from the southern outfall on March the 15th, "1882."

Examination continued by Mr. Bidder.

15,643. In the diagram No. 3 upon the southern outfall there is a very remarkable thing, is there not?—The table of analyses of the proportion of albuminoid ammonia on page 12 shows that the quantity of albuminoid ammonia yielded per gallon by a sample collected immediately at the outfall was ·336, decreasing to ·066 above Crossfield's manure works. I should mention that those are taken from the southern outfall to Jenningtree point. Above Crossfield's manure works, as I say, it is ·066, the sample being taken a short time after 9.30, the exact time not being given; it took from 9.30 to 11 o'clock to take the samples from the outfall to Jenningtree Point. The albuminoid ammonia off the powder magazine further decreased to ·036, off the manure factory it was about ·038, at near Jenningtree Point ·033, and off Jenningtree Point ·028. The diagram shows all that very clearly; the diagram is drawn to scale, so that the relative distances can be seen at once.

15,644. Then I believe you wish to take diagram No. 5 next, will you just explain in your own way what is the particular object of this diagram. I see it shows that during the whole of that period the maximum of albuminoid ammonia was ·042?—The analyses of those samples is given in Table No. 2, page 3.

15,645. (*Dr. Stevenson.*) I see the vertical lines are ten times the value that they were in the other tables?—Yes; because in this case I am dealing with river waters, and it would have been impossible to have got it upon the paper upon the same scale as in the other diagram. The analyses are on page 3, they are a series of samples of river water collected off Woolwich arsenal in mid-stream, at high water and one hour after high water, from August 12th, 1880 to October the 18th, 1880.

15,646. (*Mr. Bidder.*) In the first place, the maximum upon any occasion is ·042?—The maximum is ·042 on October the 12th.

15,647. Usually the general run of that diagram shows that the albuminoid ammonia was very much below that?—Taking the average of the whole, it is ·028. The minimum of albuminoid ammonia in those samples was on August 12th and September 23rd, when it was only ·021.

15,648. There is a very remarkable thing about that diagram, you have also plotted upon that diagram in dotted lines the amount of chlorine?—Yes, I have plotted out upon that diagram the amount of chlorine.

15,649. Which of course gives a rough idea of the proportion of sea and fresh water?—That is so.

15,650. All the samples were taken at corresponding periods of the tide, were they not?—The high water sample being taken at the top of high water, and the other about one hour after high water.

15,651. It is a curious thing to notice upon that diagram that the occasion when the pollution was at its maximum as indicated by the albuminoid ammonia, viz., the 12th October, was the occasion when the chlorine was at its minimum, showing that it was the occasion when floods had reduced the proportion of the sea water to an abnormal extent?—Yes.

15,652. When the proportion of water from above was greater than the sea water?—Yes, that is so.

15,653. On the 9th of October 1880 the chlorine drops in a very remarkable manner, whilst at the same time the albuminoid ammonia jumps up upon the diagram?—Yes, that is so.

15,654. (*Dr. Stevenson.*) May I ask how you explain that?—I can only explain it by presuming that the character of the water that comes down the river was as impure as that which is in the neighbourhood of Woolwich at any time, or more impure; because it is a notable fact, if you look at this diagram, that, the higher the quantity of sea water which must come up from below the outfalls and with the sewage in it from the outfalls, the less the pollution as indicated by the albuminoid ammonia.

15,655. (*Mr. Bidder.*) The dotted line here represents the chlorine or sea water, and the sea water only comes to Woolwich after passing the outfalls?——Yes.

15,656. Therefore the dotted line here represents the water at Woolwich which has come past the outfalls?—Yes.

15,657. (*Chairman.*) I take it that the analyses for chlorine and albuminoid ammonia are taken from the same sample?—They were, that is most important.

15,658. (*Mr. Bidder.*) Consequently, when the dotted line rises, the proportion of water from below Woolwich to the water coming down from above is greater. When the dotted line falls the proportion of land water is greater?—That is so.

15,659. Indicating floods, I suppose, in the upper river?—Yes.

15,660. So that we see that the general rule upon the face of this diagram is that when the proportion of water which is coming past the outfalls to Woolwich is less the pollution is less, but that when the proportion of water from above Woolwich is greater the pollution is greater?— Yes, that series of gaugings shows that most distinctly.

15,661. Indicating that the main causes of pollution at Woolwich are rather to be sought above Woolwich than below?—They certainly do not come from the neighbourhood of the outfalls.

15,662. I see you have indicated another thing. You have indicated when the spring tides occurred, and, as one would expect, we see that with the spring tide there comes an accession of chlorine?—Yes, and a lower proportion of organic pollution.

15,663. (*Mr. Lumley Smith.*) Have you corresponding observations upon the same day at low water?—No; the difference between those samples is not very great, taking the general result. The lines in blue, which represent high water, and the red lines one hour after high water, cross one another, but out of the 20 days upon which the samples were collected the high water was the best upon 13 days.

15,664. (*Mr. Bidder.*) Do you point out that, comparing the blue line, which is the sample at high water, with the red line, which is the sample an hour afterwards, and which is water coming from higher up the river, in 13 days out of 20 the blue line is the

*Mr. W. J. Dibdin.*

13 June 1883.

better of the two?—The blue line is the better of the two.

15,665. The red line is more frequently above the blue line, showing that the water which came from higher up the river was more polluted than that which came from lower down?—Yes, that is so.

15,666. Diagram No. 6, I think, is the next?—Yes.

15,667. That represents samples taken the next year?—Yes, they were taken from 15th August to 5th December 1881.

15,668. Those were taken an hour before high water, were they not, off Woolwich Arsenal?—Yes, and the analyses are given on Table 3, Nos. 95 to 102.

15,669. Here your two colours represent something different from what they have done in the previous diagrams?—Yes.

15,670. All the samples are taken an hour before high water, but your red line represents the mid-stream sample, and your blue line the one near the shore?—Yes, over low-water mark, taken one hour before high water, one sample in mid-stream, and one sample over low-water mark.

15,671. (*Chairman.*) You mean vertically over low-water mark?—Yes.

15,672. (*Mr. Bidder.*) The red is rather the better of the two as a rule?—The general result of the analyses shows a slightly higher degree of organic pollution, but very little; the curve represents the relative quantity of the organic ammonia. The mid-stream samples will be seen to contain less impurity than those collected off the shore. The red line runs generally underneath the blue line; there are variations, the lines crossing one another now and then, but, on the whole, there is a less pollution in the mid-stream samples, and this is one hour before high water, when the water was running up the river from the outfalls.

15,673. How does the question of the contrary action of the ammonia, as compared with the chlorine, show upon that diagram. It seems to indicate, though not so strongly, the same thing?—Though not so strongly, yet decidedly the same tendency is shown there that, the lower the chlorine, the higher the pollution.

15,674. You have some samples in October 1880 and in November and December 1881. Do they relate to any diagram? There are some prominent instances, I think, which bring out very clearly what you have already indicated, that the water at Woolwich is largely affected by some source of contamination higher up the river?—The analyses seem to show that. I do not pretend to explain it, but certainly that is the conclusion one is obliged to draw from a consideration of the analyses. The average quantity of albuminoid ammonia in the Woolwich samples during 1881 varies a little from those examined in 1878, and later in 1882. The variation is very slight, but such as it is, is in favour of the present period. In 1878 the mean quantity of albuminoid ammonia from samples collected off Woolwich was ·0317, in 1880 it was ·0286. At Woolwich, in 1878, you will find on page 1 of the Tables and on page 4, Woolwich, 1880, it is ·0286, showing rather a decrease. In 1881, if we take the samples from the same spot at Woolwich Arsenal, it is ·0373, which is rather a higher degree of pollution, in 1882 it is ·0277, and in 1883 ·030, showing that there is a decrease.

15,675. So the general run of these figures shows a slight oscillation, but no deterioration, in the general condition of the river?—Decidedly; there could have been no accumulation of contamination. Whatever the impurity of the river, whether the quantity of albuminoid ammonia is a perfectly true index of the absolute quantity of organic matter, or not, hardly matters, because we find that, whatever it is, it is relative. When dealing with the same description of nitrogenous matter as we find in sewage, we find there is no accumulation, that it is a little higher at one time and a little lower at another, but that, taking it year by year, there is no accumulation.

15,676. Now take diagrams Nos. 7, 8, and 9. I think those are to show the conditions of different parts of the river, the different depths from the surface?—On 27th July and 3rd August 1882 samples were collected at half-flood and half-ebb upon the surface of the water and two feet above the bed of the river at Blackwall, Woolwich, Barking Creek, and Erith; that is shown by Diagrams Nos. 7, 8, and 9, which are upon the same page. Diagrams Nos. 7 and 8 extend from Blackwall to Erith, and Diagram 9 from Crossness Point to Erith Causeway.

15,677. The result of these analyses generally is apparently that there is no very great difference whether from the bottom or top of the water?—No; the point is that the mixture of the impurities in the river, the sewage, or whatever it may be, is a tolerably constant mixture. If we look at Diagram No. 8, it will be seen that the quantity of albuminoid ammonia at Blackwall at half-ebb at the surface is high, and then it decreases to Woolwich, and that it is the same exactly at the Northern Outfall as the bottom sample, and a trifle higher at Crossness, and getting a little lower again at Erith. The lines cross one another, and there is no conclusion to be drawn from it except that the mixture is complete.

15,677*a*. Now, referring to Diagram No. 10, the effect of that is to compare the mid-stream with the shore flow upon the ebb tide?—On 24th August 1882, during three-quarter ebb, samples were collected 200 yards from either shore and in mid-stream off Crossness Point and Erith Causeway; they were taken to ascertain whether there was any difference in the character of the water flowing at either side of the river, and the practical result is that at Crossness Point it is exactly the same on either shore, rather better in mid-stream, and at Erith Causeway the mid-stream is still the best, but the differences are very slight indeed; there is no practical variation; drawn upon this scale, they look more important than they are.

15,678. Now I think we want to go back to Diagram No. 4, which we have skipped; that will show the samples taken upon the 31st August and 1st September 1882, taken at all periods of the tide?—Yes.

15,679. This is a diagram which will show the changes in the condition of the samples of water at that spot at those periods of the tide?—Yes.

15,680. And also with the chlorine dotted?—The chlorine follows the tide.

15,681. As one necessarily expected, the chlorine is lowest at low water and highest at high water?—That is so. On 31st August the river at low water, having received the sewage from the outfalls, was naturally at its worst, after two hours' flood its character was improved by the water from below. At high water it was at its best, and becoming worse at quarter-ebb. On 1st September, after the scour of the river by the exceptionally high tides of the 31st, which were 1½ inches above Trinity high-water mark, and which must have carried the impurities of the river a considerable distance down stream, the water was a trifle worse at half ebb than at a corresponding time of tide on the previous day. It was about the same at three-quarter ebb, and considerably better at low water, notwithstanding the sewage of the outfalls. As the flood came up, bringing with it a certain proportion of the polluting matters previously carried down, the impurity increased to a maximum for the day at high water (when it was less than at low water on the 31st), and at quarter-ebb fell again to one half.

15,682. Speaking generally, from all those analyses does it become manifest that the organic pollution of the Thames, speaking for the period of six years over which they extend, is practically constant, and not an increasing quantity?—That is so, as I have shown before. The figures at Woolwich would apply with slight variations to any other portions of the river; that is to say, at high water and low water, as the

case may be, there are variations, but the average result of it all is that it is very much the same during the period of six years.

15,683. Is that constant or practically constant quantity such a quantity as could be reasonably supposed to be either dangerous to health or a source of annoyance to people passing along the river or living upon its margin?—The various analyses which have been made of the Thames water show that the organic ammonia yielded by samples collected above Teddington Weir is only from half to a third of that in samples taken at Woolwich, so that, if we deduct the additional quantity of organic matter which the river receives in its downward course through the shipping, &c., it will be at once seen that, if the water at Woolwich and other points in the neighbourhood of the outfalls is contaminated by the Board's sewage works, it can only be to a trifling extent, an extent not greater than that present in ordinary London drinking water.

15,684. You say the ammonia yielded by samples taken of the water above Teddington, as compared with ·03, which one may take as a rough average of your samples all through, will be found to be about half to a third of that at Woolwich, that is to say, from ·01 to ·015?—Yes.

15,685. Then you have sources of contamination between Teddington and Woolwich, which add to that?—Yes.

15,686. Which would make it more than three times?—The difference between the quantity at Teddington and at Woolwich after deducting the quantity which we may reasonably conclude is due to the shipping, &c. is very slight.

15,687. If I remember rightly, that is clearly confirmed by Dr. Tidy's analyses?—Yes.

15,688. I think that the same result comes out from that, that the purity of the water in the neighbourhood of the outfalls is from two and a half to three times what it is where the people of London have it taken from to drink?—Yes, speaking roughly, not having the figures before me.

15,689. (*Dr. Stevenson.*) That is before filtration, you mean, as it comes over the weir at Teddington?—Yes.

15,690. (*Mr. Lumley Smith.*) Is that based upon these albuminoid ammonia investigations?—Yes.

15,691. I do not think Dr. Tidy at all based any conclusions upon that?—No, I do not know that he did.

15,692. (*Mr. Bidder.*) That concludes all the diagrams; then you have some tables; I believe you wish to refer to Table No. 5 on page 12?—Yes.

15,693. What is to be noticed in those samples?—That the water in the Victoria Docks, in Deptford Creek, Bow Creek, and Barking Creek, is on the whole worse than the water in the River Thames in mid-channel. *Mr. W. J. Dibdin.* 13 June 1883.

15,694. (*Chairman.*) Were these samples taken in the docks or in the river outside the docks?—One sample was taken inside the docks.

15,695. Was it taken near the middle or entrance, or the upper end, or where?—I think it was taken in the middle of the docks as nearly as may be. I do not know the exact point, but right inside the dock.

(*Mr. Bidder.*) The others, of course, are taken in the Deptford Creek at low water.

15,696. (*Mr. Lumley Smith.*) It would make a material difference at what part of the Victoria Dock that sample was taken?—I will let the Commissioners know that; there you get 0·066, which is twice as much as we get in the river water.

15,697. Take Deptford Creek and Bow Creek, both of which have feeders, they seem to indicate they are rather worse than the water of the River Thames?—Yes, that is so.

15,698. And you would say that that which feeds Barking Creek is very much worse?—In some cases, on March 14th, 1878, for example, it is ·081, and the average taken in the two years 1878 and 1882 was ·048.

15,699. (*Dr. Stevenson.*) Were the samples taken after there had been any storm outfall overflowing?—I cannot say that.

(*Mr. Bidder.*) I will make some enquiries about that.

(*Mr. Lumley Smith.*) I should like also to know the point where the samples were taken in Deptford Creek.

(*Chairman.*) Unless you have the position where those samples were taken, their value is diminished by, it is impossible to say, what extent; you had better, as the Americans say, locate the point of the collection of the water samples.

15,700. (*Mr. Lumley Smith to the witness.*) None of these samples, as I understand, were taken by you?—No, only one or two.

15,701. (*Mr. Bidder.*) I think you have taken some samples of what was coming into the river from other places?—As regards the sewage from sources other than the Metropolitan outfalls.

15,702. And the Chiswick ones?—That sample I took myself, that was the sewage; I have put forward no sample in any table, the collection of which I cannot prove.

Adjourned to Tuesday next at half past 12 o'clock.

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# FORTY-FIRST DAY.

## Tuesday, 19th June 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
WILLIAM POLE, Esq., F.R.S., *Secretary.*

Mr. HENRY LAW called again; further examined by Mr. NORMAN BAZALGETTE.

15,703. (*Mr. Norman Bazalgette.*) Sir John Coode asked Mr. Law for the area of the Crossness section on the line D.D. (*To the witness.*) Will you give that?—I have taken that out for 1833 from the survey of Captain Bullock and Captain Burstal. The sectional area at low water was then 20,445 square feet. In 1861, from the survey of the Thames Conservators, it had been enlarged to 33,780. In 1864, from the survey of the Metropolitan Board of Works, it had already diminished to 28,770. From the soundings of *Mr. H. Law.* 19 June 1883.

*Mr. H. Law.*
13 June 1883.

the Metropolitan Board of Works in 1879 it had then been increased to 33,850 square feet. We have no soundings subsequently.

15,704. Are they all upon the same line?—Yes, they are all upon the line D.D. Then I wish to point out one matter with regard to the section put in by Mr. Mansergh. I would observe that the line at the bottom of this section, which represents the low-water area, does represent the low-water area in 1878 from the commencement as far as the line 5. W.; it also represents the same thing from 2. E. to the lower end of the section; but between the point 5. W. and the point 2. E. it represents the area in 1861 upon the north half of the river combined with the area in 1878 upon the south side, and therefore does not represent anything comparable with the other part of the section. But the whole red line is that which represents the area in 1878, and is therefore a continuation of the black line upon the other part of the section.

The witness withdrew.

Mr. William Joseph Dibdin called again; further examined by Mr. Norman Bazalgette.

*Mr. W. J. Dibdin.*

15,705. When we broke off upon the last occasion you were going through your various tables, explaining each of them. I think we broke off at Table No. 4; was that so?—Yes.

15,706. What does Table No. 5 contain?—The Commission will remember that we were obliged to pass Table No. 4 and go to Table No. 5, and so go to the end of the tables and come back to Table No. 4, No. 4 being put in this position for the convenience of the lithographer in putting it upon the paper. The next point we come to is the sewage from sources other than the Metropolitan Board of Works outfalls. Before considering this, with the permission of the Commission, I should like to go back to sample 232 on page 12, the Victoria Dock sample. But before passing to that, I beg to hand in the table of analyses of the London sewage which were referred to last week, when unfortunately the tables were not ready. (*The tables were handed in.*) Now No. 232, on page 12, represents a sample taken on March 25th, 1878. Some doubt was thrown as to the correctness of that sample, it being so long back as the 25th of March 1878; it is a sample I am in hopes of being able to prove the collection of before the Commission; but as there might be some little doubt about it, and as I have not yet been able to identify the collector, to overcome any objection upon that score, I had an additional sample collected yesterday morning at about half-past eight, about 100 yards inside the Inner Lock, 20 minutes before the lock gates were opened; so that that sample may be taken as a fair sample of the dock water. I found that the albuminoid ammonia yielded by that sample was ·059, the chlorine being 150 grains per gallon; so that the sample in 1878, as will be seen, yielded albuminoid ammonia equal to ·066, and this equal to ·059; showing that even now the character of the water in the Victoria Docks is much worse; it is more than twice as bad in many cases as the Thames water, taking the average of Thames water; it contains more than twice as much nitrogenous organic matter as the Thames water.

15,770. When you speak of the Thames, where do you mean, do you mean above or below the outfall?—I am speaking generally, because the condition of the Thames varies according to the tide and the rain water, and so on; but, taking the general run of the Thames water, not immediately in the line of the outfalls, but taking mid-stream samples, the Victoria Dock water contains twice as much organic impurity as the Thames water.

15,708. (*Chairman.*) What part of the river do you speak of?—The neighbourhood of the outfalls.

15,709. (*Sir John Coode.*) Where would that indicate?—Say, from Woolwich to down below Erith.

15,710. (*Chairman.*) Another thing is, what time of the tide would you speak of?—When I say "twice as much," I am taking the general average of both high and low water.

15,711. I suppose the Victoria Dock is supplied from the Thames, is it not?—Yes, it is.

15,712. And it has some contribution of sewage, I suppose, internally?—Presumably so, from the matter which appears in the docks.

15,713. What would that be from; would the men use their privies, or whatever they are, on board ship?—I presume so. I believe there are regulations in the docks that the men are not to use the accommodation usually provided on the vessels, but, beyond all doubt, they do not observe the regulations. At all events, this is the analysis and the actual result obtained from a sample of the water; wherever the pollution came from, there it is.

15,714. (*Sir John Coode.*) The same regulation would apply to what we may call the offal or waste in preparing the vegetables and meat cooked on board, and all that sort of thing?—I am not able to speak from personal observation with regard to that.

15,715. (*Chairman.*) I am rather at a loss to perceive the utility of this; if the same regulation does apply, what then?—It amounts to this, that, if the water of the Thames is so polluted as to have an injurious effect upon the health of those living upon it, surely the dock water would have the same effect.

15,716. (*Dr. Stevenson.*) Have you compared the water in the Thames at high water with the water in the Victoria Dock?—Yes. By turning to my samples in 1880 and 1881, taking 1880 first, which are given in Table No. 2, page 3, beginning at No. 25, and going on to sample No. 28, and every alternate sample after that, you will find the analyses of samples taken at high water off Woolwich Arsenal, and if you look at the column of albuminoid ammonia, you will find it varies; as, for example, ·021, ·033, ·025, ·034, ·028, and so on; the average for all the samples, one at high water and one at one hour after high water, being ·0286, or rather less than half that in the Victoria Docks.

15,717. (*Sir John Coode.*) That in the Victoria Docks being ·066?—·066; and ·059 by the sample collected yesterday. Off Woolwich Arsenal, again, on August 15th, 1881, will be found, on page 6, No. 95, a series of samples which were taken at one hour before high-water, one sample being taken in mid-stream, and one sample being taken vertically over low water mark; so they were taken just before high water, and may be taken as fairly representing high water. There it will be seen that the maximum upon any occasion was ·056, being an exceptional sample altogether; and four days afterwards, upon the 19th August 1879, the albuminoid ammonia was ·021. And, looking down the column, it will be seen that the average which is given at the bottom of this series, on page 8, was ·037 for that year, being the year in which the worst samples had been taken off Woolwich Arsenal, and then it was only ·037, whereas in the docks we have ·059 and ·066.

15,718. Were they taken year by year?—Yes, since 1878, with the exception of 1879, when we were engaged in the Mud Inquiry.

15,719. (*Mr. Norman Bazalgette.*) I do not know whether you have instituted a similar comparison for albuminoid ammonia between the average Thames water and the water found in Deptford and Bow Creek?—Yes. We come to Deptford Creek at samples Nos. 233 and 234, in Table No. 5, on page 12. On October 30th, 1882, the albuminoid ammonia was equal to ·040, and on November 1st to ·057, being an average of ·048. These samples were taken some little way up the creek at dead low water, so

that the water which was in the creek then was that coming down from the creek; it was not Thames water which had gone up and come down again, as it might have been if we had taken it at any other time of the tide. It was dead low water in the river. All the water had come out of the creek then, and a sample was taken of the water then flowing down the creek, a boat being taken up the creek as far as it could go.

15,720. (*Sir John Coode.*) What would be the population draining into Deptford Creek at the point above where the sample was taken?—That I am unable to say.

15,721. Is it large or small; it would depend upon that, of course?—I believe there are a number of factories which drain into it, and a good deal of land-water drains into it. Then you have Bow Creek. On April 3rd, 1882, a series of samples was taken off the Thames Ironworks, off Iron Bridge, off the Four Mills, and off Bow Bridge.

15,722. (*Chairman.*) Where is Bow Creek?—Bow Creek is just below Blackwall. The Thames Ironworks are situated at the corner of the creek.

15,723. Is it at the outlet of the Lea?—Yes, it is.

15,724. Then you have got lower down than Deptford now?—Yes. There the albuminoid ammonia is seen to be in the first ·042, varying to ·032, the mean being ·033, which, although much the same, is rather worse than the ordinary Thames water.

15,725. (*Sir John Coode.*) That is just half of the proportion in the sample that you have got from the Victoria Dock?—Yes.

15,726. (*Chairman.*) That is better than Deptford Creek, half the Victoria Docks, and worse than Jenningtree Point, which is No. 280?—Yes. A question was asked last week whether any overflows had taken place shortly before the samples were taken in Bow Creek on April 3rd. I may mention that the rainfall at Greenwich upon March 26th, 1882, was ·67 of an inch, and that no rain fell from March the 26th to the date of the collection, April 3rd, so there had been no recent overflow, even if there was an overflow upon that occasion, which I am unable to say. Then passing to page 13, we come to Barking Creek, where we have samples taken in 1878 on different dates, and on April 12th, 1882, when a similar series of samples was taken to those in Bow Creek. There we find that on March 14th, from a sample taken mid-way between the outlet and the town of Barking, two hours before low water, when the creek water was coming down, we obtained albuminoid ammonia equal to ·081. On the 22nd, two hours before high water, it was ·057, showing that when the river water was going up, having mixed with some of the creek water, the mixture of the creek and river water was much worse than the river water itself. On November 16th, 1878, in a sample taken some distance from the mouth of the creek at dead low water, when there was a quantity of tarry matter coming down in the creek water, floating upon the surface to such an extent that it was not only perceptible to the eye, but the odour of the tar was very distinct in the atmosphere, even on the deck of a tolerably good-sized steamer, in that sample the albuminoid ammonia was ·051. That was undoubtedly a sample of Barking Creek water without much river water; that is shown by the quantity of chlorine, which is 2·88. Now the water shown at the mouth of the creek is 153·0 of chlorine just at half ebb, so there could not have been much sea water in that sample of November 16th. When I say "sea water," I am speaking of it as a mixture of sea and river water. If there had been no river water, there could have been no sea water. Then following down the samples, upon April 12th the albuminoid ammonia went from ·034 to ·038, the total average for the samples collected at Barking Creek upon the different dates being ·048, or considerably higher than the river water.

15,727. (*Chairman.*) Is it conceded that albuminoid ammonia, if any, is a dangerous material?—I think so. The other side have used it in their evidence.

(*Mr. Balfour Browne.*) It is certainly not conceded at all; it was used by two of the chemists who gave evidence before you, and they both said that it was useful up to a certain point, but not a reliable or an accurate test of the impurities in the water.

(*Chairman.*) Does Mr. Dibdin's evidence differ from that which was given upon your side?

(*Mr. Balfour Browne.*) Yes, and considerably in many respects.

(*Chairman.*) Does it differ in that you make a greater quantity of this objectionable matter?

(*Mr. Balfour Browne.*) Yes, we make it a greater quantity, and we say we have taken it by processes which are reliable; whereas we say the albuminoid process is not a reliable or an accurate test.

(*Witness.*) I think we shall be able to show, both from my own evidence and from the evidence of the chemists who are to follow me, that this is a very reliable test, and a test reliable not only for the purpose of telling whether there is a greater or less quantity of sewage in water, but a test which is used by chemists almost universally as a guide in telling them the quality of ordinary drinking water, not merely as a test for sewage, but as a test of a perfectly pure water compared with this; and if it is so delicate a test, and is used so universally, not only in England, but elsewhere, and is generally admitted as an indication of relative purity, surely, your Lordship, I think, will agree with me that we are entitled to use it in estimating the value of such a water as the Thames.

15,728. (*Chairman.*) I suppose some albuminoid ammonia in water would not make it deleterious?—It might, undoubtedly, or, on the other hand, it might only be a small quantity present from vegetable contamination. In fact, I think I am right in saying there is hardly such a thing known as a sample of water which will not yield a more or less quantity of albuminoid ammonia. Even if we take pure, distilled water, by which I mean ordinary distilled water, and treat that in the same manner as I treated this, we have a quantity, not a large quantity, but a trace, a very small quantity, of albuminoid ammonia; we actually get it there. If we take water containing a slight contamination, we get a little more albuminoid ammonia; as the character of the water decreases, the quantity of the albuminoid ammonia increases, until from, perhaps, 1000th part of a grain we come to sewage, which will give us, in some cases, from one to two grains; ordinary London sewage, as I shall show from my analyses, containing something less than half a grain. So that we have a very wide range; indeed, I think the Commission will agree with me, when they have heard the whole of the evidence, upon this point, that this method of analysis is an exceedingly delicate and reliable one, not one which gives, as I stated last week, the actual amount of organic impurity, but the relative amount of organic impurity.

15,729. (*Sir John Coode.*) I think I asked you upon the last occasion whether there was any other method or any better method?—There are several other methods, for example, the estimation of the organic carbon and the organic nitrogen. There is a method of estimating the quantity of oxygen absorbed from a solution of permanganate. I think Dr. Tidy stated in his evidence that that method is not to be relied upon when dealing with sea water containing a quantity of chlorides; but I believe that other chemists, who have studied this question very carefully, have found methods of conducting the process which do give them reliable results in dealing with water containing sea water.

15,730. (*Mr. Balfour Browne.*) That is the permanganate process, is it not?—Yes; but when we are dealing with a mixture of sea water, river water, and sewage, and goodness knows what besides, I am certainly of opinion that there is no better method

*Mr. W. J. Dibdin.*

19 June 1883.

known which can be used as a guide in estimating the quantity of nitrogenous organic matter in the water.

(*Mr. Norman Bazalgette.*) Perhaps, in answer to your Lordship's question, you will allow me to read an answer from the evidence of Professor Heaton upon the subject; he was a chemical witness called by the other side. He was asked, at question 11,357, "Will you tell us the particular constituents for "which you tested?" and his answer was, "Those "which appeared to us to be most important were "two in number, first, the examination of what is "called albuminoid ammonia, and, secondly, the deter- "mination of dissolved oxygen. (*Q.*) Those are the "two important ones? (*A.*) I do not say that they "are the only important ones, but we regarded them "as very important for our special purpose."

15,731. (*Dr. Stevenson to the witness.*) Referring to Dr. Heaton's evidence, which was given upon the 7th of March, he gives certain tables of albuminoid ammonia and other constituents; have you compared your own results with those obtained by Professor Heaton, and drawn any conclusion?—No; for this reason, that Professor Heaton stated, and I think his analyses show, that his method of operation was different from mine in that he included a great quantity of suspended matter in his albuminoid ammonia.

15,732. (*Mr. Norman Bazalgette.*) I was going to put a question which would have made that a little clearer. I was going to ask the witness whether he had imitated Professor Heaton's example and filtered his sample?—No, that is not so; Professor Heaton did not filter his samples, but in all my samples the mud was allowed to settle and the clearer water drawn off for analysis.

15,733. (*Dr. Stevenson.*) Your sample did not represent the whole of the albuminoid ammonia then?—The whole of the albuminoid ammonia in solution. The question of the suspended matter is a separate question, because it is evident, if you take a sample of the Thames water immediately after a steamer has passed by, you get a certain quantity of mud mixed up; and if you include that mud in your water and make an analysis of it, you will get altogether different results from what you will if you take the clear water alone. In the former case the albuminoid ammonia will form a measure, not of the soluble organic matter, but of the amount of solid impurity present or stirred up.

15,734. Your samples represent clear water, and Professor Heaton's represent muddy water?—Mine represent the water as you obtain it after allowing it to settle down for, say, 24 hours. Now Professor Way put in a number of analyses of samples which were taken upon the 14th and 22nd of September, and in those he gave estimations of the quantity of albuminoid ammonia; and I think, looking at it roughly, because Professor Way has taken his proportions in parts per 100,000, and I have taken mine in grains per gallon, but looking at the figures, they are practically the same as my own.

15,735. (*Mr. Norman Bazalgette.*) Then you and Professor Way are agreed pretty nearly in your figures?—Decidedly so. For instance, upon September the 14th samples were taken at Teddington by Professor Way, in which the albuminoid ammonia was ·13 and ·12. If we go to Barking upon the same date, we find that the albuminoid ammonia was ·21 and ·24, or only twice as much as in the water taken up at Teddington; and that is confirmed by my own analysis that the albuminoid ammonia is from two to three times as much at Crossness. And upon the same days he has two or three times as much. In the first sample he gets less than three times as much as at Teddington, and in the other only twice as much as at Teddington, figures which agree very closely with those which I have laid before the Commission.

15,736. (*Dr. Stevenson.*) Were Professor Way's analyses made with filtered water?—I cannot say, but I believe he treated them in the same way as I did, namely, that the suspended matter was allowed to settle. In fact, I think he must have done so, looking at the results, otherwise the results would have been very much higher. Now on page 13 of my tables, at Nos. 246 and following, a number of analyses are given of sewage from sources other than the Metropolitan Board's outfalls. Perhaps this would be the fitting time at which to call your attention to the tables of analyses of London sewage, which I have in the second book of tables which I have handed in. Turning to page 6, at the bottom of the page, I give the average of the samples from both outfalls which were examined for albuminoid ammonia, the samples being collected in the method I stated last week, and at the times shown in the tables. Taking the average of the samples collected from both outfalls during the months of March, April, and May, the albuminoid ammonia seems to be ·383; this is at page 6. In these tables of figures you will see that the first sample on page 1 was taken at the southern outfall on March 23rd and 24th, 1883. They were all taken during the months of March, April, and May from the two outfalls. I may tell the Commission the object of these tables. I do not wish you to go through all these figures; it would be unfair to suggest it. I simply wish to call your attention to my results. I may state the object at once for which these analyses were made. The Commission will remember that there was a considerable controversy during the evidence that was given on the other side as to the quantity of suspended matter in ordinary London sewage, and we had some very big figures put before the Commission, and the analyses which had been previously made to ascertain this point were called into doubt. In order to settle this question as far as possible, I had this series of samples collected, and the result of it all is given in the third line of the average results at the bottom of page 6. Taking the average of samples from both outfalls, we find, speaking of albuminoid ammonia, that the albuminoid ammonia yielded by these samples is equal to ·383. At this point I might correct a figure I gave last week. I said ·366; that was the southern outfall, the average at both the outfalls being ·383. The average quantity of suspended matter in sewage being 27·39 grains per gallon. Dr. Tidy, in his evidence, stated that he believed the average quantity of suspended matter in London sewage, taking wet and dry weather together, would be nearer 50 grains. The Commission will therefore see at once that it is a very material question, as to the quantity of solid matter discharged into the river, whether we discharge 27 grains into the river or whether we discharged 50 grains.

15,737. (*Chairman.*) By "grains" you mean grains in weight, do you not?—Yes; I have mentioned before that, if we treat the ordinary filtered water supplied by the London Water Companies, we may get ·005 or ·006 or ·007 of a grain of albuminoid ammonia per gallon, but if we take the sewage, it is ·383. In some cases it is very nearly one grain, ·8 or ·9 of a grain per gallon. And sometimes the sewage, from the increase of rainfall, is weaker, but ·383 represents the average, the London filtered water being ·005 or ·006. Now, having those figures for comparison, I go to sample 246 upon my 5th table, page 13, where we have a Chiswick sample, taken on the foreshore at 12.45 p.m. on August 16th, 1882. This was a sample of sewage collected by myself upon the foreshore at low water. As we were proceeding up the river, we noticed that the sewage was being discharged from the outfall at Chiswick. It came down over the lip of the sewer, and ran down the foreshore, and so into the river. We were unable to get a sample of the pure sewage, so we got a sample of the mixture of sewage and water, as it was running into the river, taking care to get it as nearly pure sewage as we could. But this Chiswick sample gives us albuminoid ammonia equal to ·31, which is only a trifle less than we get at the Metropolitan Board of Works outfalls. So that, if the chemists upon the other side have said, as I believe they have done, that they have found sewage up as far as Chiswick, I am not at all surprised.

(*Chairman.*) I thought we had given up Chiswick.

(*Mr. Norman Bazalgette.*) I think your Lordship drew the line of the influence of the river upon health at Rotherhithe.

(*Witness.*) The only object of this is to show that, if traces of sewage have been found at Chiswick by the chemists upon either side, there is no reason why they should not have found them ; and, that being so, I would leave the upper river and go to North Woolwich. The same table, at No. 247, gives us a sample from the North Woolwich outlet, which is just below the pier at North Woolwich, near the gardens there, so that, if anybody crossing the river at low water found a smell arising when the paddles of the steamer were stirring up the mud, it is not surprising. We find the sample taken on October the 16th, 1878, at 9.40 a.m., gave us albuminoid ammonia equal to ·217, and that at Beckton Gasworks upon the same day the sample gave us albuminoid ammonia equal to ·135.

(*Chairman.*) But will you tell us your results instead of giving us the figures in detail.

15,738. (*Mr. Norman Bazalgette.*) Does that determination as regards the Beckton Gasworks show that the gasworks discharge something other than gas drainage?—Yes. Then we will pass to a more interesting subject, namely, the discharge from the sewer at Erith at low water when the mud is all uncovered.

15,739. (*Dr. Stevenson.*) Could you give us the volume flowing from these places?—The discharges vary considerably. At the Beckton Gasworks upon one occasion there was a considerable quantity being discharged.

15,740. (*Chairman.*) Did you take your Erith sample from the pipe discharging immediately into the river?—Not discharging into the river, but discharging on to the foreshore.

15,741. And you found it exceedingly foul, did you?—I did.

15,742. Unless you can give the comparison of the volume that was discharging into the river as compared with the volume of the river itself, what does it prove; we know that sewers are foul?—My object is to show that these samples were exceptionally foul, far fouler than anything obtained from the Board's or other sewers, except at Erith. My evidence goes to prove that it is foul, and that it is discharged on to the foreshore when that part of the foreshore is not covered with water, and that under the heat of the summer sun even a small quantity of that exceedingly concentrated sewage may give rise to what have been described as stale water-closet odours. The quantity of albuminoid ammonia yielded by this sample was equal to 3·70 grains per gallon, and I may say that the odour from that sample was the worst I ever smelt from any sample I ever analysed. This was taken at a point off the flour mills just above the Causeway; and from personal inspection I can state to the Commission that any question of liquid sewage is not to the point with regard to these Erith cases; but that from a slaughter-house adjacent there was actually lying upon the beach—upon the hard stones and gravel above the soft mud—slaughter-house refuse, guts and gall bladders, and so on, solid sewage refuse and various other matters, and the atmosphere upon a comparatively cool day, at that spot (and there were boats and men working just about there), was exceedingly obnoxious.

15,743. (*Mr. Norman Bazalgette.*) Was what you saw quite sufficient in your judgment to account for the complaints which we heard from the Erith people about the smells at low water?—A very great deal more than sufficient. I could not have believed any such state of things existed anywhere along the banks of the Thames, and when I saw that I was exceedingly surprised, it was far more than enough to account for anything I have heard.

15,744. (*Chairman.*) You do not refer so much to the general bulk of the pollution as to its offensiveness at that particular point?—As far as the bulk of the pollution goes, it would be a mere drop in a bucket if put into the river in a proper manner, but, lying in a heap of solid matter, it is exceedingly offensive.

15,745. (*Mr. Norman Bazalgette.*) I believe you have made determinations over a considerable period—over the last six years—for chlorine in Thames water in the neighbourhood of London Bridge?—Not only near London Bridge, but elsewhere in the river; but in the samples of Thames water at London Bridge which I have examined, the chlorine has at no time exceeded five grains per gallon.

15,746. What inference do you draw from that?—The inference I draw from that is that the quantity of sea water which comes up to London Bridge is exceedingly minute ; and I may say at once that the two occasions upon which I obtained four grains per gallon are given on page 9 of volume 1 of my tables at Nos. 187 and 188. On March the 12th, 1883, at No. 187, on the surface and 20 feet below the surface, at 4.45 p.m., two samples were taken, and also on March the 10th two samples were taken ; on Saturday and Monday, when exceedingly high tides prevailed in the river, so much so that people barricaded their walls for fear of having an overflow, and it will be seen upon the first day (the Saturday the 10th), when the tide came up the chlorine was 2·1 at the surface and 2·2 20 feet below the surface. On the Sunday the high tides prevailed again, and also on Monday the 12th, when the amount of chlorine in consequence of the high tides had risen to 4·1 and 4·2 grains per gallon, which is very different from the 140 grains which have been put in by the other side. This is my experience. In exceptionally high tides and in exceptionally dry weather the quantity would be higher.

(*Chairman.*) The object of this is to show, is it not, that the sea water does not come up to London Bridge, and does not bring sewage with it in great volume, and that the river at London Bridge is not poisoned?—Yes.

15,747. (*Mr. Norman Bazalgette.*) Now will you pass to the suspended matter, and tell me what steps you have taken to arrive at a conclusion with regard to the suspended matter in the London sewage?—The results of the analysis are in volume 2, which I have put before the Commission, that is to say, the total quantity of suspended matter in the London sewage in April and May of this year, as shown in the tables, is equal to 27·39 grains per gallon.

15,748. I believe the tables show that you have taken the effect of the rainfall into consideration?—Yes, the rainfall is shown in the column headed "Rainfall at Greenwich."

15,749. (*Prof. Williamson.*) Is that the average made up from any determinations of different states of rainfall applying to the quantities, or how is it obtained?—It is obtained as shown in the tables ; we took samples at every four hours at the outfalls. In the case of the southern side, all the sewage runs through one long length of sewers down to the outfall, and then passes through the pumps. We took a sample just as it came from the pumps, so that it was thoroughly mixed up, that was at 6 o'clock, and then another sample at 10, and so on every four hours. Now upon the northern side the sewage runs down to the outfall through three sewers, we therefore took a sample from the lip of each sewer at one time, and mixed them together, and that would be the sample, say, at 6 o'clock, and we should do the same thing at 10 o'clock again as before, and every 4 hours. The hours of collection are given with the rainfall at Greenwich.

15,750. The quantity of rainfall and sewage representing each determination, or how?—No, the figures show the quantities present in each gallon of the sewage, the quantity would vary with each quantity of sewage discharged.

15,751-2. So that this does not profess to represent what would be the average; but you collected all the sewage and mixed it?—I think it does represent the average as nearly as we could possibly get it.

*Mr. W. J. Dibdin.*

19 June 1883.

15,753. Before it could do that, you must know how much of each quality there was?—I am afraid it is a matter about which there is considerable difficulty. I have tried to do the best I could.

(*Mr. Norman Bazalgette.*) Will you next state what you have done in order to ascertain whether there has been any considerable variation in the character of the mud in the neighbourhood of the outfalls during the last few years.

15,754. (*Chairman.*) Would you mind first of all telling us the result which you have found, and your conclusion from your experiments?—I have found generally that there is no practical difference whatever in the composition of the mud from the various banks in the neighbourhood of the outfalls between the years 1879 and 1883. I have had samples taken in precisely the same spots as those collected in former years, analysed as nearly as possible in precisely the same manner. The results are shown in my table, and the general result is that there is a composition there which is exactly the same as it was.

15,755. How many years ago was that?—Between the years 1879 and 1883.

15,756. (*Chairman.*) It seems to me that that is not a momentous question. You do not know, I suppose, what was the composition of those banks in the same places before the outfalls, do you?—I am afraid I do not.

15,757. Have you made a comparison between those banks and banks not subject to the influence of these outfalls; for instance, a bank of mud above bridge, now?—In the present instance, I have not. That was so fought out in the arbitration, and such a number of analyses were then put in, showing that the composition of the mud in the River Thames throughout its whole length is fairly uniform, that, that question having been settled, it was thought if we could show now that the banks in the neighbourhood of the outfalls have not increased in polluting matter, and that the composition of these banks is the same now as it was then, we should have answered that question.

15,758. That is to say, it was then shown that the mud in the neighbourhood and under the influence of these outfalls was the same as the mud of other parts of the River Thames, and you show that it has not got worse now?—That is so; that is the pith of it.

15,759. (*Mr. Lumley Smith.*) The witness must not take it that that was admitted on all hands in 1879?—That was the distinct finding of the arbitration.

(*Chairman.*) But the result of the arbitration had nothing to do with the composition of the banks, had it?

15,760. (*Mr. Norman Bazalgette.*) There was, I think your Lordship will find, a finding of the arbitrator upon that very subject, viz., the composition of these very banks in respect to sewage. (*To the witness.*) I think you have also taken samples of Thames water off Erith, for the purpose of determining the amount of suspended matter in them?—Yes, that is page 14. But on the same page samples are given of the mud which would be skimmed, as it were, off the immediate surface, and mud taken from 6 inches below the surface, and there I find that the sample upon the immediate surface, as will be found from the analysis, taking the quantity of mineral matter, contains rather less mineral matter, that is to say, rather more organic matter, than what is contained in the sample from 6 inches below; in other words, it is rather more impure. But that is taking it upon the immediate surface, as you would skim it off with the point of a penknife. It was taken to see whether there was any difference in the mud, and the difference is shown very distinctly, the sample from 6 inches below being of the same composition as the ordinary banks of the Thames, and the sample upon the immediate surface being, as I say, a trifle worse; but not even then being anything like sewage as shown by the analysis. The quantity of organic matter in the sewage mud from the floor of the reservoir, being 34·68 per cent., that in the mud upon the immediate surface at Erith Pier is only 14·28 per cent.; and, as the estimation of the nitrogen shows, the organic matter, although considerably less than in sewage—a difference of 14·28 per cent. against 34 per cent.—the nitrogen in the organic matter in the mud is only 4·69 per cent., against 5·34 per cent. in sewage.

15,761. (*Chairman.*) What is the bulk when you say 34 per cent. 34 per cent. of what?—Of the dried mud from the sewage. A sample of that portion of the suspended matter in the sewage which settles to the bottom of the reservoir is taken and the water evaporated off until the sample is perfectly dry, and then it is burnt, and we find that the loss on ignition is 34 or nearly 35 per cent.

15,762. (*Chairman.*) Do you mean 34 per cent. of the suspended matter?—No. If we take the whole suspended matter in the sewage, we shall find upon my other tables that the organic matter is equal to 54 per cent.

15,763. Take a gallon of water, what percentage of suspended matter is there in it?—That I have not worked out. This is the dry material.

15,764. It is 34 per cent. of the dry matter that you are speaking of?—The organic matter in the mud deposited in the reservoir is 34 per cent. of the dry matter.

15,765. (*Mr. Norman Bazalgette.*) I believe you have been at some pains to take a sample of mud from a tidal river which was free from all possibility of pollution with sewage?—I have. Having the opportunity, I obtained a sample of mud from the River Fitzroy in Queensland. I wanted to obtain a sample of water in which there should be no symptom of pollution. The town of Rockhampton is situated below the point at which the sample was taken, and furthermore it is a non-sewage river, because Rockhampton is a privy town essentially. The sample was sent me by my brother who is in Queensland.

15,766. I believe you have been there yourself?—Yes, I have resided in Rockhampton some little time. I know the river perfectly well, and I know that it is free from all sewage contaminations. I find that the mineral matter present in the dried mud of this sample is 94·8 per cent. It is only a little more than what you have in the Thames, where it is 85·72, the volatile matter in the Queensland sample being 5·2 per cent. The estimation of the nitrogen and phosphoric acid per cent. of dried mud gives 2·37 and ·24 respectively, showing that the amount of organic matter as represented by those figures is less than we find in the Thames mud, but not much less.

15,767. Is it less by a half?—No. If we take samples 14 to 20, we find the average percentage of nitrogen is 2·7. Taking the average of samples 3 to 12 in 1879, we find that the nitrogen in the organic matter is 3·48, and the same samples in 1883 give 3·6; whereas, if we take the Rockhampton sample, it is 2·3.

15,768. (*Chairman.*) What does it come to; that their river is better or worse than the Thames?—It shows that that river, which is a perfectly pure one, contains organic matter to nearly the same extent as the Thames does.

15,769. Does not that prove too much, because it would go to show that there is no organic matter in sewage?—No, certainly not, because we get 5·2 in the Fitzroy mud. There is very little difference, that is what it comes to.

15,770. (*Mr. Norman Bazalgette.*) Does it show this, that the organic matter which is present in the sewage does not get into the mud?—Yes, it does to a certain extent, and it does show that to a certain extent the mud is polluted, but to such a small extent as to make no appreciable difference.

15,771. I believe that you have taken some pains to ascertain the temperature of the water at various times?—Yes, I have inspected the river upon a number of occasions, having visited the whole length of what may be called the sewage zone, that is from

Greenwich to Erith and Purfleet. During the summer of last year I was frequently upon the river, and although the temperature of the water upon some occasions went nearly up to 70 degrees, yet the odour from the river water was nothing more than you would find either down at Southend or up at Teddington. In fact, it is not noticed until you take a small jar or vessel half full of water and shake it violently, then, on smelling it, there is what his Lordship has described as a sedgy odour, that and nothing more. Anything which would indicate sewage I have never noticed, unless we were in the sewage line. When we were following the sewage down from the outfalls, it follows the figures of analysis in the most wonderful manner, the sewage odour rapidly disappears, and even on shaking up the sample of water you get little more than the sedgy smell which you get in any river water.

15,772. Upon the numerous visits you have made to the river, have you noticed the smell of the factories?—Yes, I have noticed it very strongly indeed. Upon the numerous occasions when I have been down the river, the odour of the factories has been very strong. I have never been down the river but what the smell from one or other of the factories has been very powerful indeed. There are numerous manure and chemical factories situated on both sides of the river, and as the river winds about, whichever way the wind blows, you are bound to have the odour from some of these works, you cannot get away from them, and at times the odour from the works is extremely nauseous. I can easily understand the evidence which has been given by fishermen upon the river that the odours are extremely unpleasant, but those odours come from the factories and not from the river water. I have been down the river frequently in the summer time, and I have tried to isolate myself from the Metropolitan Board of Works view of the case, and to see what I could find as an independent individual, and I can conscientiously say that I have never been able to find any odour from the water except near the outfalls. When you are in the line of the outfalls you do find a smell from the outfall sewage, but that soon disappears as you follow it down, and upon a cold windy day you hardly notice it even when you are at the outfalls; but as you get down further by the works you notice a nauseous smell from the factories.

15,773. (*Dr. de Chaumont.*) You stated that the difference between the amount of organic matter as represented by nitrogen in the Queensland sample, compared with that of the average of the Thames mud, was inappreciable?—It is not put in the tables, but if you will insert after sample 20, and between that and "Erith Pier," the mean of samples Nos. 14 to 20, you will see what I mean. The mineral matter present is 89·52, this is excepting sample No. 17, which it will be seen is a sample of fine sand and coal dust, and could not be called mud. Mean of volatile matter 10·48, nitrogen per cent. of dried mud ·314, nitrogen per cent. of the volatile matter 2·97, and the phosphoric acid ·487.

15,774. Even then you will find the volatile matter is twice what it is in the Queensland sample, that the nitrogen per cent. of the dried mud is 150 per cent. higher?—The indication would be the nitrogen per cent. of the volatile matter, which is 2·37 against 2·97, while, if you take sewage, it is 5·2. Now I admit at once that in the mud there is a certain quantity of organic matter present; but, considering one is a pure natural river with comparatively no traffic upon it, no refuse from boats or barges and so on, and that the total quantity of volatile matter is less, the nitrogenous matter in the Rockhampton mud would naturally be less. Furthermore, we must bear in mind that the mud of the Thames contains a number of worms, in fact, everybody admits that all along the Thames there are worms, you cannot take a sample along the Thames without finding worms and minute infusorial life, which exist to a very great extent, so much so as to affect analyses; and in estimating the nitrogenous constituents of the organic matter we ought not to neglect the fact that animal life does exist in those samples, so that, if we deduct the amount of nitrogenous organic matter which we find by reason of the existence of these organisms, there is very little left to come from the sewage.

Cross-examined by Mr. Lumley Smith.

15,775. I understand that you have based the greater part of your calculations with regard to the pollution of the Thames upon the consideration of the albuminoid ammonia?—Yes, I have.

15,776. I believe you are a disciple of Mr. Keates upon the subject, are you not; he did the same thing?—Yes, and many of these analyses, as I think I have stated, were made by myself under the immediate direction of Mr. Keates. I was working with him during some part of this time.

15,777. I was going to ask you whether that process which is called "Wanklyn's process" has not of late years been given up by a great number of chemists?—Indeed not. I have heard of its being given up by one or two, but the great majority of chemists still use it.

15,778. When you say "the great majority" still use it, it is a very rapid and easy way of getting at some result, is it not?—It is a rapid and easy way of getting at a result, but not in all cases a reliable result. To obtain accurate results, and results which will be strictly comparable, requires very great care. If you adopt a rapid and easy mode of doing it, you may get any result you like, as you may with any chemical process.

15,779. I believe the opinion of chemists is divided upon this subject?—There are a good many who still use this process.

15,780. And a good many who do not?—And possibly a good many who do not.

15,781. I believe Dr. Frankland gave it as his opinion that it was not to be relied upon at all. It does, in fact, give you no clue as to what the albuminoid ammonia comes from; you cannot tell what the source is from which it comes when you find the albuminoid ammonia?—There are very few processes which will give you the actual composition of the organic matter in a sample of water; if you could find one which did, it would be an extremely valuable process; but I know of no such.

15,782. It gives you no notion of the source from which the albuminoid ammonia comes, does it?—I think it does in this way. If we take sewage, and treat it by this process, we get a certain result; if we take a mixture of water with sewage, and treat it in the same way, we get a certain result, and we are fairly entitled to say the thing is reliable to that extent.

15,783. You stated it as your opinion the other day that the albuminoid ammonia is now taken as an index of the amount of putrescible nitrogenous organic matter; that was so, was it not?—Yes, that which may be in a putrescent condition, or likely to become putrescent; that is, as I stated, nitrogenous organic matter, whether it is in a putrescible condition or not.

15,784. Could you venture to say that it did not give any index of non-putrescible organic matter?—It does not take into account the carbon; it takes only into account the nitrogen.

15,785. Is it not the fact that a great many things yield a great deal of albuminoid ammonia?—No doubt it is a fact, but it depends upon how you treat them, and what process you adopt.

15,786. Then a great deal of albuminoid ammonia might come from matters which were non-putrescible, and not likely to become putrescible?—Yes, that is so.

*Mr. W. J. Dibdin.*

19 June 1883.

15,787. I will give you a few examples. I am told that some bodies yield about half their nitrogen as albuminoid ammonia, is that not so?—Yes, it is.

15,788. And some yield the whole?—Yes.

15,789. Some yield half, some two thirds, and some one third, and some a quarter?—Yes, that is so.

15,790. And some none at all. Some which have nitrogen yield no albuminoid ammonia at all?—I believe there are some; I cannot say; I do not know it from actual experiment.

15,791. I suppose uric acid, for example, is a matter which goes into the river in the form of urine?—One would think so.

15,792. Is it not the fact that uric acid is a thing which yields very little or no nitrogen as ammonia?—I cannot say that, I have not made the observation.

15,793. So that what I put to you is this: there might be a vast quantity of urine in the river, although it would show no albuminoid ammonia?—That raises the question of the free ammonia.

15,794. But would you confine yourself to the albuminoid ammonia?—You are asking me about things which I cannot confine to albuminoid ammonia.

15,795. But I have your opinion that uric acid yields little or no nitrogen as ammonia?—I never tried it.

15,796. Take urea; is it not the fact that that yields no nitrogen as ammonia at all?—I have not made actual experiments upon the urea.

15,797. I have pointed out to you that there may be in the water elements of pollution which may yield no albuminoid ammonia?—There may be.

15,798. May there not be on the other hand a great deal of albuminoid ammonia which results from causes which are quite independent of sewage pollution, are you able to tell me that?—There may be, but in the case of the Thames I do not think there are.

15,799. Have you analysed or seen an analysis of any water of the river Shannon?—I have not.

15,800. The Shannon is a very peaty river, is it not?—I do not know that, I am not acquainted with it.

15,801. Is not peat a thing which would yield a vast quantity of albuminoid ammonia?—It undoubtedly would yield a vast quantity of albuminoid ammonia, but we are not dealing with the river Shannon or a peaty river.

15,802. I am dealing with Wanklyn's process, and I am asking you whether you may not get a great deal of albuminoid ammonia in water where there is no sewage?—You may under exceptional circumstances, but now we are dealing with the Thames, and the Thames is not under exceptional circumstances.

15,803. I am asking you whether you may not find a great deal of albuminoid ammonia in a river water where there is no sewage?—You might under exceptional circumstances.

15,804. Peat will produce it to a considerable extent, will it not?—Yes, it will.

15,805. And other matters will do it?—Peat will yield a considerable quantity of albuminoid ammonia, I believe.

15,806. Is not the result of it this, that the mere fact that albuminoid ammonia is found in water does not prove whether it comes from sewage, or whether it comes from peat, or what it comes from at all?—Not in all cases, decidedly not.

15,807. Is it not the fact that it varies, as one of our witnesses said, most capriciously in different parts of the river?—If you simply take the figures without any consideration of the circumstances, it does vary considerably; but if you consider the time of the tide, the height of the spring or neap tide, and the rainfall, and so on, you will find there is nothing capricious about it.

15,808. It wants a good deal of consideration, does it not, in order to get at the conclusion you want to get to?—You have to study the whole of the surrounding circumstances. At first it seems as if you could get no definite opinion from it at all, it all seems as if there were no order and regulation in the thing whatever, until, after making a series of examinations, you become acquainted with various surrounding circumstances, and it then becomes as clear as can be.

15,809. It comes to this, that at first sight your samples show no plan, and no order, but that after consideration you can evolve a theory out of them?—It shows at first sight that the river is not polluted with sewage or anything to such an extent as to cause a nuisance, and, independently of chemical analysis, common observation shows the same thing.

15,810. You are wandering away from the result of your previous answer. At first sight it shows that there is no order and no plan in the result of your observations?—At first one does not know why it is that if one takes a sample of water from Woolwich upon one day we get perhaps albuminoid ammonia represented by 20, on another day we take a sample and get perhaps 30, and we cannot perceive the reason of the variation; but, whatever the variations are, the impurity in the water does not approach sewage at any time or anything like it.

15,811. That is a matter of argument?—It is a matter of actual observation and fact.

15,812. Having stated what are the results you arrive at, is it not the fact that most chemists are giving up the Wanklyn process?—No, it is not the fact.

15,813. Have you tried the combustion process at all?—I have tried it, but I have not generally adopted it, it is one that occupies a considerable amount of time.

15,814. And the other is easy and quick?—The other is easier and quicker, and I believe is more reliable.

15,815. Many chemists adopt the combustion process, do they not?—I do not know. I believe they do.

15,816. Take Dr. Mills of Glasgow, for example?—I daresay he does.

15,817. And Dr. Odling?—Many chemists use it, but I believe that it is open to so many sources of error that it is hardly worth while adopting it.

15,818. Now you found that you had to take 181 samples, had you not, before you could evolve any theory out of it?—No, a single sample would have done that.

15,819. But you have already told us that a single sample would have left you very much in the dark?—I am speaking of river water; but, whether it is river water or sewage or anything which fluctuates in its character day after day and hour after hour, an assumption based upon a single analysis may be right if you happen to hit upon a mean sample, but if you get an exceptional sample, your result must be fallacious.

15,820. May I take it that in your results of albuminoid ammonia in sewage you find very great fluctuations?—Undoubtedly.

15,821. You did your best to prevent their fluctuating more than you could help, because I see in your volume 2 you took three samples and mixed them together. I find on the first page "Mixture of three "samples from pumps taken at 6 p.m., 10 p.m., and "2 a.m." Why did you mix the three samples?—Because it would be impossible to do the work otherwise without a large staff of assistants, that is to say, if all these were to be examined separately. If we were to take a particular sample at any time, we might have a strong sample or a weak sample of sewage, according as that might represent day or night sewage.

15,822. The result of mixing three samples together at intervals of four hours is that you never get a strong sample?—Undoubtedly you do. You get fair average samples.

15,823. You never get a strong sewage over eight hours?—Undoubtedly you do.

15,824. Then why do you mix them up? If 6 p.m. would be strong sewage from any particular pipe, then 2 in the morning would not be, would it?—No, it would not be so strong.

15,825. Is not the result this, that you are always diluting your specimens?——

(*Chairman.*) He is strengthening his 2 o'clock specimen.

15,826. (*Mr. Lumley Smith.*) It never gets either very strong or very weak?—The next samples are taken at 6 in the morning, 10 o'clock in the day, and 2 in the afternoon, and I have mixed them together.

15,827. (*Sir John Coode.*) Mr. Lumley Smith wants to know what is the strongest?—Will you kindly turn to page 7 of the second volume; there I give you each sample separately, the first being collected at 4 o'clock a.m.

15,828. (*Mr. Lumley Smith.*) But here you do not give us the albuminoid ammonia?—It was not necessary in that case. It would involve such an amount of work, and the average would be the same thing.

15,829. The fact is, you have not given us the albuminoid ammonia for any single sample?—It would have been too much trouble. There were 24 samples taken upon a single day, and it would have been impossible to have done the work.

15,830. (*Chairman.*) In fact, you have not done that?—I have not; the table shows that.

15,831. (*Mr. Lumley Smith.*) There are five chemists attached to the Metropolitan Board of Works, are there not?—Yes, but these were not done by the five chemists.

15,832. You have drawn my attention to page 7 of your tables; that does give us the result of some analyses of single samples, that is to say, it gives us the chlorine and it gives us the suspended matter?—Yes.

15,833. Those were all taken upon the 29th and 30th of April, were they not?—Yes, they were.

15,834. And there is one upon the 12th of May?—There is a series given on the next page, taken on May 12th and May 13th.

15,835. Are not those dry-weather months?—You may call them dry-weather months; but there was a considerable quantity of rain fell, as I show upon page 7, "Series of Samples collected upon the Southern Outfall," and the rainfall at Greenwich was ·22; at Spring Gardens it was ·34; on May 12th at Greenwich it was ·33, and at Spring Gardens it was ·430; so that those were wet-weather samples and not dry-weather samples.

15,836. Do you represent 27·29 as the ordinary average of suspended matter; is not that the dry-weather average of suspended matter?—No; if you look through the column, you will find that a good deal of rain-water fell, and then, including the dry with the wet ones, you get a fair average.

15,837. What is the highest quantity of suspended matter that you have here; you have one of 27, one of 32, and one of 44. One of 52 seems to be the highest, does it not?—On page 6 of this table there is as much as 76·9 grains per gallon.

15,838. But I want the single samples. Why are you so shy in adopting my suggestion that 27 is the dry-weather quantity?—I deal with the facts; the samples are taken in wet and dry weather, and the actual observation of the analyses gives me 27·29.

15,839. But it does get up, in fact, to 76?—Will you also kindly point out that it does go down to something like 10.

15,840. It must go down if you are to get your average?—On the 29th of March, No. 116, at the northern outfall it is 10·5.

15,841. What is the highest you have ever found?—I think the highest that was ever found was a sample put in by Mr. Keates in the arbitration case, when it came to something under 100, and that was immediately after a heavy storm of thunder, lightning, hail, and rain passed over the metropolis.

15,842. Other people have found 146 grains, have they not?—I have no doubt that under exceptional circumstances you may find even more.

15,843. Heavy rain, as a matter of fact, will give you a very large quantity of suspended matter?—No doubt you will at a particular time find a very large quantity, but after the first rush, if you take a fair average of the samples for the day, not an isolated sample for an hour, you will then get a fair average quantity.

15,844. But it increases for some hours, does it not?—It will increase it for a time. I dare say, when that sample containing 76 grains per gallon was collected, if we had waited till the worst came and then taken the highest figure we could get for the moment, we might have made something more of it.

15,845. The result is, is it not, that in the tables you have given us there are none of an exceptionally high number?—Yes, the 76 one is an exceptionally high one; that is the average for 12 hours; if we had taken one sample upon every hour during 24 hours that occasion, we should have shown some very interesting figures.

15,846. Now, as to your diagram. I do not understand the analyses that were made in 1878?—I thought I had explained them already.

15,847. Why were any samples taken in 1878?—It is known to the Commission, I think, that in 1877 a report was made to the Thames Conservators by Captain Calver as to the condition of the river Thames, and in reply to that Mr. Keates, then consulting chemist to the Metropolitan Board of Works, was ordered to carry out a series of investigations as to the state of the Thames, and in that way a number of samples of Thames water were taken and analysed. Those examinations were made by myself, at least some of them were, and those that were made by myself I have made use of for this present inquiry.

15,848. You will hardly call those 1878 ones that are put into your table No. 1 a "large number of observations," because they are very few; have you picked them out, or were there others?—Those are all that were actually made by myself; there were others taken by other people.

15,849. Are those all that you analysed?—Those are all that I analysed. In 1878 there were 22 samples altogether.

15,850. They are spread over a good many months, are they not?—Yes, throughout the year, and in different places.

15,851. I do not find at any place more than two samples?—We cannot analyse the whole of the river; we have done a good deal of it.

15,852. However, that is the reason you say?—And later on after that, towards the end of the year, after the "Princess Alice" accident, when the complaints were made, further samples were taken.

15,853. The "Princess Alice" went down in the beginning of September?—Yes.

15,854. Will you point me out, with the exception of the two that I see in March, any that were taken in the spring of the year. Out of the whole of your pages 1 and 2, I only find two that were taken in March, one at the northern outfall on March the 11th, and the other at Crossness.

15,855. (*Mr. Michael.*) There were three taken at Crossness?—Other samples were examined.

15,856. (*Mr. Lumley Smith.*) But they are not here?—Because I did not examine them.

15,857. And you do not show the state of the tide in any way on page 1?—Yes, I do in numbers 5, 6, 7, and 8. No. 1 was 5½ hours after high water at London Bridge, and the Victoria Docks 6½ hours after high water; it was an omission not to put that in.

15,858. At Woolwich you do not give us the state of the tide?—No, that was an omission.

15,859. Now we will take Table No. 2. Why have you taken Woolwich as your place at which to make all your observations?—Because at that time there were a very great number of complaints, that is to say, so far as we heard, the major part of the complaints came from Woolwich, and that was considered at the time a very good starting point from which to examine the river, and there the samples were taken.

*Mr. W. J. Dibdin.*

19 June 1883.

15,860. What is the deduction you draw from page 3 at Woolwich, where you give a number of double observations at high water and after high water?—If you turn to Diagram 5 at page 16——

15,861. What deduction do you draw from that?—The deduction which I draw in the first instance is that the contamination of the river at that point is immaterial; it is so small that it really does not come into the question at all as affecting the river from the point of its giving forth emanations which are noxious to people who are travelling upon it or living near it; that the water, according to the state of the tide and the rainfall and other circumstances, varies; that it is not the same thing, but that there is a tolerable mean, and that the variations are very slight.

15,862. You have taken it at high water and an hour after high water; do you draw any deduction from that system of bracketing, as I may call it, the hour of high water with the hour after high water?—Yes, I do.

15,863. What is your deduction from that?—I say that, if we take the high water, which is the water from below the outfalls, and which must receive the sewage from the outfalls, and, as we are told, ought to be the horrid polluting stuff it is said to be, that that ought to be much the worst; but if we look at the figures throughout, we find it is not so; we find that the high water samples which should contain the sewage are on 13 days out of 20 best instead of worst; they contain the least pollution.

15,864. If you turn to your table at page 3, you will find that in No. 28 at high water there is more albuminoid ammonia than there is an hour after, there you get for the high water ·0220, and for an hour after high water you get ·0210, so that there is more albuminoid ammonia at high water?—If you will look at the diagram, you will find it is so shown.

15,865. The following day it is just the reverse, so that there is no law apparent; these lines cross each other?—I simply pointed out the fact that upon 13 days out of 20 the high water was the best, but the general conclusion to be drawn from it is simply that the water was not in the horrid condition in which it is said to be.

15,866. If you confine yourself to that, that is one thing; but I thought you drew a comparison between the state of the water at high water and an hour afterwards?—And so I do draw a comparison between water at high water and water an hour after high water.

15,867. Now your diagram No. 1 is to illustrate your sharp line of demarcation, and I understand you to say with regard to your two blue lines that one was taken at one end of the boat and one at the other, to show that there is so very much more organic matter in the sewage than there is just upon the other side of the line?—It is the red lines which were taken from the boat.

15,868. What do the blue lines indicate?—I took one 200 feet from the northern outfall and the other at 600 feet.

15,869. So far as the blue line is concerned, it teaches nothing, does it?—It is not so sharp.

15,870. But one is taken at 200 feet from the northern outfall and the other is taken at 600 feet?—Yes, that is clear.

15,871. If you look at diagram No. 1 with regard to your red lines, does one represent the observations taken at one end of the boat and the other the observations taken at the other end of the boat?—Yes.

15,872. I suppose the sewage flow is at times a good deal more than one boat's length across?—Yes, but this is right away from the outfall; this does not represent the sewage stream at all.

15,873. I just want to understand the wording of your statement at page 11; what do you mean by the "shore side of line of junction"?—As the sewage comes out from the outfall it meets with the river water, and there is a very distinct line of junction with the river water where they meet.

15,874. There would be two lines, would there not?—It is not so noticeable upon the shore side; it is where the body of the river water meets with the sewage.

15,875. You have taken the line, have you, out towards mid-stream?—Yes, but it is very close in towards the shore as compared with the bulk of the river water.

15,876. Now I want you to look at diagram No. 2 on page 15; you give there the amount of albuminoid ammonia near the surface and the amount three feet from the bottom?—Yes, on August 11th.

15,877. Does not that show that there is more albuminoid ammonia at the surface than there is at the bottom?—Immediately near the outfall; at the outfall it is precisely the same; but then, if we go to Barking Creek, there is rather more at the surface there, and also at Lawes' Chemical Works; but as we follow that line down, we find, when we get to the two powder magazines, about 1,000 yards or a little more than 1,000 yards, it shows that the mixture is practically complete and remains so.

15,878. Is it not the fact that the polluted stuff is more apt to remain at the top than to go to the bottom?—At the outfall it is so, but the distance is really nothing upon the river; upon the diagram it seems a good deal, but it is really nothing, because we have taken only from the outfall to Crossness Point, which is a very short distance indeed.

15,879. Now with regard to the next diagram, No. 4; you made a remark upon that diagram, and also with regard to the next diagram, No. 5, that the more chlorine there is, the less albuminoid ammonia you get; is not that so?—At Woolwich that is so, but at Erith we are below the outfalls and in a different condition of things.

15,880. Is it not so everywhere that the water is better at high water all along the river?—No.

15,881. Professor Heaton gave us that difference. I ask you, do not you agree that at high water you find noticeably less ammonia all along this part?—Not at all.

15,882. But let us look at your diagrams; your diagrams, as far as they go, all show that that is the case?—Which of them, because these diagrams show totally different things?

15,883. Do not these diagrams all show that, as the chlorine mounts, the albuminoid ammonia falls?—It is so with regard to the Woolwich diagram.

15,884. Is it not so with regard to all of them?—No, it is not so with regard to Erith.

15,885. Will you point out where it is not so?—I am referring to low water at Erith, diagram No. 4; there on the 31st August the chlorine at Erith is low and the albuminoid ammonia is high——

15,886. That proves the same thing, that they go in opposite directions?—But next day we find it is different.

(*Mr. Michael.*) If you look at page 5, and take the contrast between high and low water, there is the answer to your question. The albuminoid ammonia upon that page at low water is ·0192 and the chlorine 1·27. When you come to high water the albuminoid ammonia is increased to ·0278 and the chlorine is 10 times as much, namely, 12·04. There is an increase, therefore, of albuminoid ammonia with 10 times as much chlorine.

(*Mr. Lumley Smith.*) But you have got up to Blackwall.

(*Witness.*) But you asked me if it was not so throughout the whole length of the river.

(*Mr. Michael.*) The albuminoid ammonia at Erith at low water is ·02 and the chlorine 13·2, and at high water the chlorine is nearly 10 times as much.

15,887. (*Mr. Lumley Smith.*) And that water at Blackwall pier is water which has come past the outfalls?—But when we are at low water at Woolwich we have less chlorine than we have at London

Bridge, and we have the water at Woolwich at dead low water which was at high water further up the river.

15,888. Do not you find that, as the sewage water comes in, the albuminoid ammonia stands in its relative proportions?—The diagrams do not show that; they show the water coming up (*referring to the Woolwich diagram*) which had received the sewage, and we find it better than the water which has gone up further and come down. At the same time, I do not wish to draw too much inference from that view. What I say is that, if we take the very worst time of the water in the river, as shown by the figures, yet the condition of the water is not such as that it can become offensive.

15,889. Passing to diagram No. 4, I notice you have observations of two consecutive days; the dotted lines represent the chlorine upon those two days, and those are pretty much constant; you get about the same sea water at this time of the tide?—Yes.

15,890. But I find that the amount of albuminoid ammonia is exceedingly different on those two consecutive days?—Yes.

15,891. So that on two consecutive days you find with the same amount of sea water a very different amount of pollution, as evidenced by the albuminoid ammonia?—Yes.

15,892. Does not that show that albuminoid ammonia is a process which does not give you any fair results?—No, on the contrary, I think it is a point which brings out the character of the albuminoid ammonia test very satisfactorily indeed.

15,893. Why so?—Because upon the first day those samples were taken, as I think I mentioned in my evidence-in-chief, it was an exceptionally high tide, and at low water we had the water charged with the sewage from the outfalls, it had just come past the outfalls and had received sewage, and was to a certain extent rendered worse than it was before. That is the effect of that day's tide. Then, the night's tide and the next day's tide coming into play, there being an exceptionally high tide, there is a very considerable scour of the river; the quantity of impure water which was in the river has been carried out and replaced by the fresh water from the sea; and we find, in consequence of that, that upon the second day samples taken at the same place give us a less impurity.

15,894. This great bulk of sea water washes out the river, is that so?—Undoubtedly it is so, I think the diagram shows that the albuminoid ammonia agrees with the common sense of the thing.

15,895. You have no observations corresponding to those at Woolwich in diagram No. 5, lower down the river, have you?—No.

15,896. According to the lines there the chlorine is always less an hour after high water, have you any corresponding observations to those lower down the river?—No, I think I have done all that was possible.

15,897. Before we pass from No. 5, the chlorine as a rule increases with the spring tides, does it not?—Yes, it should be so.

15,898. And that would be at the full moon?—Yes, or just afterwards.

15,899. When you have your full moon on the 20th of August, do you not find an extraordinary depression of chlorine, and can you give any explanation of that?—The 16th, the 19th, and the 23rd, I have.

15,900. That would be the period of spring tides, would it not?—Yes, going from neaps to springs.

15,901. Now I want to point out to you that diagram No. 7 shows the condition of the water above Barking and below Barking, it is for the purpose of comparing the state of things upon half flood and half ebb; now you see at Barking Creek, or immediately below there, the blue lines and the red lines cross each other, they are equal, if you notice?—Yes.

15,902. So the half ebb and the half flood are equally good; that is so, is it not?—Yes, at that point.

15,903. Now, when you come above the outfall, do not you find the half flood is worse than the half ebb above Barking?—When we come to Woolwich it is worse.

15,904. There is more albuminoid ammonia in the half flood above Barking than there is in the half ebb?—Yes.

15,905. Does not that show that the water which has come past the outfall is worse than that which by the half ebb is coming down from the upper river?—But may I point out to what extent that is so. It shows, looking at the scale, taking the half ebb at the surface and the half flood at the surface, the difference between ·023 and ·025, being a difference of ·0020. In London drinking water we get ·005, so that the difference is not so much as we get in ordinary drinking water, in fact, the difference is so microscopic that it is of no moment.

15,906. Now if you will look at No. 7 at the bottom, you will see that the bottom is the worst throughout?—That is very natural indeed.

15,907. Now if you look at No. 8 at the bottom, the half flood is the best throughout?—Looking at these figures, they are almost identically the same, the difference there is not more than the error due to manipulation.

15,908. Does not it all go to show that the results of albuminoid ammonia are not to be relied upon?—It goes to show that the composition of the water there is constant practically, and also it shows that the process is a very reliable one indeed, because, whatever process you use, there will always be the error of manipulation, and these differences are really little more than what that comes to.

15,909. These samples which you have taken, upon which your volume 1 is based, are all single samples, are they not, they are not taken across the stream up and down?—No. these are single samples except with regard to the Erith ones, which are samples taken across the river at three different points, and at the surface and half depth, so that each sample is really a mixture of six. We wanted to get a fair picture of the condition of that water, so we took three samples at the surface and three at half way down, and mixed the six together.

15,910. You have given us at pages 9 and 10 of your first volume the quantity of albuminoid ammonia at different places. I will take Woolwich, and I will take Greenhithe. You there show that in a gallon of water at high water you find more of the albuminoid ammonia at Woolwich than you do at Greenhithe, you find ·032 at Woolwich?—They are half flood and half ebb; taking the mean, they are ·030.

15,911. What I put to you is this, do you suggest that that is due to the improvement of the water from the albuminoid ammonia having disappeared, or to dilution from its being mixed with a larger quantity of water?—At Woolwich as against Erith?

15,912. No, at Woolwich as against Greenhithe. Have you worked it out at all by the cross sections to see how much albuminoid ammonia there is in the whole section of the river at Woolwich and Greenhithe, so as to compare the two?—No, not further than what is stated in the table. At Woolwich there is only five to six times what we find in ordinary drinking water, and twice as much as we get at Teddington, and at Greenhithe there is only four times what we get it in drinking water and less than twice as much as we get at Teddington; the difference is practically nothing.

15,913. You have not given me the amount of albuminoid ammonia in the sea water?—No, I have not done that.

15,914. Are you able to tell me whether the mixture of sewage and sea water does not turn the sulphates into sulphides?—That is a very important question, and it is so. The organic matter and the sulphates react upon one another, and sulphides are formed, and then we have ferruginous clay which is suspended in the river water acting as a purifying agent by absorbing

*Mr. W. J. Dibdin.*

19 June 1883.

the sulphuretted hydrogen so formed, and we get in that way the black colour of the mud.

15,915. It does cause the sulphuretted hydrogen to be given off, does it not?—It does not cause it to be given off, but to be immediately seized by the clay which is suspended in the water.

Cross-examined by Mr. Beaumont Morice.

15,916. I wish to ask you a question about what you said with regard to the drains of Erith; how often have you been down, taking samples from these drains?—I have not actually, with my own hands, taken samples from these drains, but I have examined these drains as recently as last Saturday, and there I found solid fæces, and, as I stated, slaughterhouse refuse, guts, and blood, lying upon the hard; so that I can well understand the complaint that is made.

15,917. Have you made any estimate of the quantity, the volume, coming out of the drains?—I have not. I am not an engineer.

15,918. What time of the tide was it?—It was at low water.

(*Chairman.*) What the witness said was this, "I "cannot tell you the quantity, either absolutely or "relatively to that of the Thames, and if it had been "discharged into the Thames in a reasonable way, it "would not have been of any consequence at all, "but I mentioned it to account for the stinks which "the people complain of; it was emptying upon the "foreshore, with a strong sun upon it."

15,919. (*Mr. Beaumont Morice to the witness.*) Did you remain there at any time?—No, but I saw what I saw, and that would remain there until the tide came and washed it away, if the tide was sufficiently high to do it; if it was not, it would remain there till the tide was sufficiently high to do it; it was not upon the mud, but upon the hard.

15,920. How far was it from the causeway?—There is a hard wall built along, coming to the foreshore just above the mud.

15,921. Did you land at all?—Yes, we landed and walked up the causeway, and went along the foreshore until we came to the drains.

(*Chairman.*) Are you going to make out that Mr. Dibdin did not smell it?

(*Mr. Beaumont Morice.*) I only wanted to know whether he was there any length of time.

(*Chairman.*) He was there long enough to smell it

Re-examined by Mr. Bidder.

15,922. I have only two questions to ask you in re-examination; is there any method of analysis known to chemists that gives you certain absolute indications as to the source of the organic matter present in the deposit?—I know of none whatever; they are all relative.

15,923. Your albuminoid ammonia, which you took for comparison, with sewage, yields, as I understand, a certain standard quantity?—That is so.

15,924. And you may get albuminoid ammonia where there is no sewage?—You may do so, but not on the Thames to any appreciable extent.

Examined by the Commission.

15,925. (*Dr. Stevenson.*) With regard to the ferruginous clay and the sulphuretted hydrogen, when that clay carries down the sulphuretted hydrogen, do you think the sulphuretted hydrogen ever comes up again, if I may use the expression, is it ever given off again?—I think not; rather I think there is oxidation going on, and the same thing happens in the water as it would in the atmosphere; the iron is converted into oxide of iron and the sulphur is set free.

15,926. You were asked about the urea in the water not yielding you albuminoid ammonia; would you not get the ammonia in one form or another from the urine in the water?—You would get it as free ammonia, the greater part of it. I think, if the analysis were carried on according to Wanklyn's instructions, you would get very little urea left; it would be all destroyed in the preliminary boiling.

15,927. Do you ever get any peaty matter in the Thames?—There is a large amount of vegetable matter in the Thames, but I should not consider the Thames would be called a peaty river.

15,928. If there were any albuminoid ammonia derivable from peat in the water, you would find it at Teddington, would you not?—We know that there is a certain amount of albuminoid ammonia derived from peat at Teddington, but we know the Thames is not a peaty river, and we know that there is a considerable quantity of sewage discharge into the river above Teddington.

15,929. (*Chairman.*) When sewage is smelt either by me or anybody else with an unscientific nose, what is it that we smell? Is it any gas, because one knows there may be a smell without any gas, such as the smell of a rose or of musk, without anything being given off; is that the case with sewage, as far as you know?—I believe it is. I cannot say that I know of anything that is given off.

15,930. You smell it, as it were, in the same way as you would smell a rose?—Yes, as your Lordship expresses it.

15,931. What causes it to cease to have that smell; can you tell me?—When the matters which give rise to that odour are destroyed, either by oxidation or other cause.

15,932. We know that practically nothing is destroyed, but that it is converted into other things?—It is destroyed as sewage.

15,933. But the materials remain?—The carbon of which a part of the sewage consists would be converted into carbonic acid gas.

15,934. What becomes of that?—That may be dissolved in the river water, and probably unite with lime or other substances to form carbonate of lime or chalk.

15,935. And some of it may go into the atmosphere?—No doubt it would.

15,936. If the water was overcharged?—Yes, as a bottle of soda-water would discharge the surplus of carbonic acid gas which it contains.

15,937. What would become of the ammonia?—It would in part be lost by evaporation, and in part be converted into nitric acid and combine with the alkaline salts which are found in the river to form nitrates.

15,938. We have heard that there is a considerable amount of solid in a man's fæces and urine. I think it was stated to be 3½ ounces a day; what becomes of that matter?—It is first of all broken up, and enters into solution with water, and then the ultimate fibres become further decomposed, and the nitrogen converted into ammonia, and so on, and the carbon into carbonic acid, the mineral matter remaining as mineral matter; that would remain in solution as carbonates, sulphates, and so on.

15,939. What would become of it?—That would enter into solution with the river water, and go out to sea.

15,940. This mineral matter would?—The soluble mineral matter would.

15,941. Or any matters which are not soluble?—Undoubtedly they would in ordinary fæces.

15,942. What would become of them?—Those would be held in suspension, and carried away with the ordinary suspended matter of the river.

15,943. They would be heavier than the river, would they not?—No; we find that the specific gravity of sewage suspended matter is little more than half that of the river suspended matter, so that, if the river suspended matter is carried out to sea, it is reasonable to suppose that the sewage suspended matter will be, if it is not oxidised and destroyed before it gets there.

15,944. The sand and gravel, and things of that sort, which are brought down, would be in suspension for some time and would deposit if an opportunity were given them to do it?—Undoubtedly.

15,945. But as to the organic matter, your statement is that it would be resolved into its constituent parts, which would either be gaseous and escape, or which would remain in suspension in the water, but, being lighter than the water, would be carried out to sea?—Undoubtedly, if they were not oxidised and further resolved into their elements by the purifying power of the river.

15,946. When this sewage first comes out you smell it?—Yes, at the outfall.

15,947. But how far do you say you smell it so as to describe it as being appreciable?—It depends entirely upon the state of the atmosphere and the wind, and so on. On an ordinary calm day, when there is very little wind, and when you see the smoke from the factories and steamers rising up into the atmosphere in a steady cloud, you may smell it when you are in a small boat for 600 or 700 yards or less, as the case may be; but if it is a rather rough, cold, windy day, and the water chopped about a bit, the odour is gone in an astonishingly short time.

15,948. Do you smell it at all on its return?—No, it goes down the river, spreads, and mixes with the body of the river water, and is for all time lost.

15,949. But it has been admitted very candidly that it must come back?—To a certain extent a little must come back.

15,950. We have heard about the wells of the fishing boats; it seems very much to be admitted to be true, that somewhere about Gravesend they can no longer keep their fish there; what do you attribute that to; to the sewage?—I attribute that not to the sewage directly, but indirectly, the sewage having absorbed the oxygen which is dissolved in the water and so rendering the water in a condition which is not fit for sustaining the life of the fish. They require oxygen in their breathing as we do, and if the oxygen is taken out of the water, then they will die.

15,951. They will suffocate, will they not?—Yes, they will suffocate.

15,952. (*Sir John Coode.*) Indirectly it is due to the sewage?—Indirectly it is due to the sewage.

15,953. By the absorption of the oxygen which is necessary for the keeping of the fish alive?—That is so.

15,954. Have you determined by actual experiment that the specific gravity of the sewage matter in suspension is, for all practical purposes, half that of the river solid matter in suspension?—Yes, and for all practical purposes it is half. A good many estimations were put forward by Sir Frederick Abel in the last inquiry which I have no doubt he will bring forward again before you, in which that was brought out very clearly.

15,955. (*Chairman.*) Although the water has lost its due proportion of oxygen, it does not become fœtid or objectionable, does it?—Indeed, no; because there is a very rapid action and re-absorption of oxygen; as it is deprived of its oxygen, it goes on to absorb oxygen from the atmosphere.

15,956. We know that at Gravesend it is salt water and in no case potable?—It is not.

15,957. Is water deprived of oxygen of itself potable?—Yes; it could be drunk as a matter of fact, without injury.

15,958. Supposing the sewage had run through fresh water instead of salt, do you say it would have become potable by that time, though it were not fit to sustain the life of fish from the want of oxygen?—I should not like to say that. The very fact of its absorbing oxygen shows that the water had contained matter which ought not to be present in drinking water.

15,959. You say that the sewage and the oxygen in the water unite; that the water becomes de-oxidised, as it were; it wants more oxygen and it absorbs it from the atmosphere?—Yes.

15,960. You also said, as I understood, that the water from which the oxygen had been abstracted could be still said to be potable and not injurious to health?—Yes, if it contained nothing injurious to health.

15,961. I thought you had made out that it contained nothing injurious to health because that would have been oxydised?—If the oxygenation were completed.

15,962. You think there is still some unoxidised sewage down at Gravesend?—Yes, a small, but a certain quantity.

15,963. (*Professor Williamson.*) I should like to ask you one question upon a matter of some importance, which I really do not clearly understand; and I think the Commission generally will be glad to have more clearly the bearings of your results which you have brought so fully before us, and that is with regard to the interpretation of the albuminoid nitrogen. You will see my difficulty better if I enter rather fully into my present state of ignorance as to your views upon this subject. You determine the albuminoid ammonia by Wanklyn's process under different conditions, at different places; and, as I understand, you use that as a measure of the noxious constituents in the water. Now, sewage consists not only of dissolved organic materials, for it is the dissolved organic matter which you determined, and not the suspended matter, but it consists also of fæces and matters of an objectionable kind which are present with it. Now, I think it would be of some importance if you were to state definitely the grounds which you have, if you have them, and if I rightly understood you, for expressing the opinion that the dissolved nitrogenised organic matter of which you get a comparative measure by this process, such as it is, is a measure of the noxious quality of the water, and that the suspended matter, not dissolved, but merely mixed up in it, is not material to it; because, of course, we know that there is solid matter suspended in it, more or less, and one is inclined, *primâ facie*, to look to that quite as much as to the dissolved organic nitrogenised matter. I presume the urea is probably decomposed before you analyse it, and that the chief sulphur compounds and the fœtid things are in the solid materials which go into the sewage, I presume. I do not know whether I have made clear the difficulty which presents itself to my mind. I have no doubt you have some definite grounds for believing that the quantity of nitrogenised organic matter which is dissolved is a measure of the noxious character of the sewage mixture, and that the solid matter does not need to be included in the calculation?—I think I have stated that I have dealt in the albuminoid ammonia estimations with that quantity of impurity which is in solution both in the sewage and in the river water, and that quantity is the most important, as I take it. The average amount of suspended matter in the sewage, as I have shown, is equal to 27 grains per gallon; we discharge the sewage into about something over 200 times its bulk of river water, and the mixture, as we see, is complete.

15,964. I thought you said the solid organic particles were lighter and floated, in the main?—I think I may say I have not dealt with the suspended matter, as you will have very full evidence given you upon that point. I have dealt only with the matter in solution as being more in my province in this case. I have had my time occupied more with that. The question of the disappearance of the suspended matter of the sewage has been dealt with by other hands, and you will have very full evidence upon that point; if

*Mr. J. Dibdin.*

19 June 1883.

you will allow me, I would rather leave that question to the Commission.

15,965. So you are not prepared to say that the dissolved nitrogenous organic matter is a measure of the objectionable character of the water?— That is one point in the case and I have dealt with it in relation to the dissolved matter. I quite admit that the suspended matter is another question, and must be dealt with separately; that has been entered into by another witness who will be called before you.

The witness withdrew.

Dr. AUGUST DUPRÉ, Ph.D., F.R.S., called in; examined by Mr. BIDDER.

*Dr. A. Dupré, Ph.D., F.R.S.*

15,966. You are a Fellow of the Royal Society and lecturer on chemistry at the Westminster Hospital?—I am.

15,967. You have known the Thames for a great number of years, I believe?—I have for 27 or 28 years.

15,968. I think you have had opportunities of generally observing the banks for upwards of 20 years?—Yes, the banks all down the river. I used to go down very often shooting at Canvey Island, near Southend, and at that time we found enormous quantities of mud there; it was necessary to have high boots up to the thigh to walk at all in many places.

15,969. What was the character of the mud?—The mud was very sticky, so that, even with the high boots, you had generally to take hold of the boot if you got into a bad place, or else it would have been dragged off. The mud was generally of a brown colour at the top, and very frequently black below.

15,970. I think, as far back as 1857 or 1858, you were engaged in conjunction with Dr. Odling in making analyses of Thames water?—We made a great many.

15,971. What parts of the river were those taken at?—They were chiefly taken at Greenwich, but we took them also up at Lambeth, and I think a little higher.

15,972. Those analyses, I think, were not conducted with the same completeness which the progress of modern chemistry has suggested?—No, they are not of a character that they can be compared with the present analyses.

15,973. Still they gave you certain indications of the condition of the water?—They did, and they brought out Mr. Baldwin Latham's mixing action very clearly; we took several samples at various parts across the river, and down to various depths, and we found quite clearly that as the tide runs up the salt water goes up the centre and in the deeper water, and leaves the sides comparatively free. The lower samples up to London Bridge frequently were distinctly more salt than the surface samples, showing that the salt water runs up below, whereas when the tide goes down the condition of things is reversed, the fresh river water then goes down the centre, and leaves the sides comparatively salt, so that there is a very considerable mixing action going on.

15,974. Does a comparison of those with the samples which you have recently analysed enable you to make any statement as to the relative purity of the river above Greenwich at the two periods?—Scarcely with regard to the water; the analyses are too different to be of any use for the purposes of comparison. I only know from being frequently upon the river, from personal observation, that there is no comparison in purity now to what it was 25 years ago.

15,975. You mean that the river is better above Greenwich?—It is infinitely better.

(*Chairman to Mr. Bidder.*) You may take that as admitted.

15,976. (*Mr. Bidder.*) Then with reference to the amount of suspended matter, how does that compare?—That was done in the same manner as it is now, and can be perfectly compared with recent results. There are some rather interesting results with regard to that; first we find that in the year 1857 the average of suspended matter at Greenwich between June and September at high water was 2·43 grains per gallon, and at low water 4·57 grains per gallon, but perhaps the more interesting point is that during the same months in 1882 we find 4·05 at high water and 3·93 at low water, but the mean comes to very nearly the same.

15,977. As regards the percentage of that which was of a volatile character, indicating organic origin, what was that?—That was determined in Greenwich in 1857 at high water as being 35·39 per cent., and at low water 26·45; that is to say, it was considerably more at high water than at low water, and the same thing happens to be the case now, only the difference is not quite so marked. In 1882 at high water it was 24·9, and at low water it was 20·2, in both cases it was more pure at low water.

15,978. There is the same excess of percentage at high water over the low, but the percentage of volatile matter is absolutely smaller in 1882 than it was in 1857?—It is very decidedly smaller.

15,979. Is one entitled to draw from that fact the deduction that the suspended matter of the river contains a smaller percentage of organic matter now than it did?—I think so.

(*Chairman.*) I do not see how this is relevant; the question is not whether you have made Greenwich water better than it was, but whether it is still not as good as it ought to be.

(*Mr. Bidder.*) I suppose everybody would admit that it is not so good as perfect water.

(*Witness.*) There is one point I should like to bring out, namely, that in 1857, when all the sewage went in above Greenwich, nevertheless the suspended matter at high water was worse than at low water, and the same is the case now, though we might come to the conclusion that it was worse now, because the suspended matter from Barking comes up the river.

15,980. (*Mr. Bidder.*) You mean that the fact that at high water you have a higher percentage of volatile matter than at low at Greenwich does not indicate the outfalls below as being the source of that volatile matter, because the same fact, obtained at a time when the sewage was put in above?—Yes, that is so. If we had only our recent results to go upon, we might come to the conclusion that the sewage discharged at Barking carried the foul matter up the river, but we cannot come to that conclusion, because 25 years ago the same condition obtained when the circumstances were reversed.

15,981. (*Sir John Coode.*) Did you make many experiments 25 years ago?—Yes, I did.

15,982. Extending over what time?—Extending over a year and a half.

15,983. When you go to Woolwich, what is the condition of things in that particular aspect at Woolwich as regards the percentage of volatile matter in the suspended matter at high water and low?—At Greenwich in 1857 it was 35·39 at high water and 26·45 at low water, that is to say, the percentage of volatile matter in the suspended matter.

15,984. (*Professor Williamson.*) Do you mean volatile, taken in the common sense?—No, that which would pass off by ignition.

15,985. Not volatile *per se*, but volatile when you burn it?—Yes, as distinguished from mineral matter. I do not wish to call it "organic matter," because it is not all organic matter.

15,986. (*Sir John Coode.*) I wish also to know what were the relative proportions of the suspended matter?—I have given them; they were 2·43 at high water at Greenwich and 4·57 at low water.

15,987. (*Mr. Lumley Smith.*) Then it was less at high water?—It was less at high water, but the

quality was much worse. Now at Woolwich at the present day it is just the reverse. The amount of matter that can be burnt off from the suspended matter in the river at Woolwich is less at high water than at low water.

15,988. (*Mr. Bidder.*) That is to say that, taking that as an indication of organic origin, the percentage of organic matter in the suspended matter, when the tide is coming up from the direction of the outfalls, is less at Woolwich than when it comes down from the upper part of the river?—Yes.

15,989. (*Professor Williamson.*) How is the proportion of solid matter per gallon of water. You say per unit of solid matter it is less, but per gallon is it less?—I have given the figures; in 1857 at high water it was 2·43 grains per gallon of suspended matter, in 1882 at high water 4·05, being rather more. At low water in 1857 it was 4·57 grains per gallon, and in 1882 3·93, which is less.

15,990. I think the Woolwich samples showed great uniformity; last year very few samples had any great excess above the mean?—There were only two samples out of some 200 samples that were above the mean as found 27 years ago at Greenwich. There was one at Woolwich at low water which was 37·2 per cent. as against 35·0, and one taken at high water at Greenwich which gives 40·3 per cent., but altogether the suspended matter in the river in that part is decidedly better in quality than it was in the river 25 years ago.

15,991. (*Mr. Bidder.*) Now, passing from the suspended matter, I will come to the samples you have taken in the last two or three years, but I should just like to ask you first with reference to the different methods of analysis as applicable to the discussion of such a question as this now before the Commission?—There are three methods now usually adopted by chemists for the purpose of estimating the relative quantity of organic impurity in water. There is no method known which gives the absolute quantity, but we can draw general conclusions. The oldest process now is that which is known as the permanganate process. The principle of this consists in estimating the amount of oxygen which the water takes from the permanganate. Dr. Tidy stated distinctly that the process was not applicable to the Thames where there was sea water, and that, therefore, he had abandoned it. But in my judgment, if it is properly worked, it is just as applicable in the case of sea water as it is in the case of fresh water. If you make the analysis in an open vessel, as Dr. Tidy according to his own description does, the permanganate process is not applicable, but if you do it in a close vessel, it gives equally good results in salt water as it does in fresh water, and we have adopted that process all through the river.

15,992. By that process do you ascertain how much oxygen is required to supply the normal quantity to the water?—No, that is not so. The more organic matter present in the water, the more oxygen it will absorb, and the less the organic matter, the less oxygen it will absorb.

15,993. Now, without going into detail, what is the second method of analysis?—The second method of analysis is what is known as the albuminoid ammonia, or Wanklyn's process, which estimates the organic matter by the amount of ammonia evolved when boiled with an alkaline solution of permanganate. That process, like the oxygen process, is only relative and not absolute, but inasmuch as in the River Thames the impurity below Teddington is everywhere sensibly the same, you get good comparative results.

15,994. That is the same process as Mr. Dibdin has been speaking of, the albuminoid ammonia process?—Yes; you get no absolute results from it, but you get comparative results.

15,995. Now what is the third method of analysis?—Professor Frankland and Armstrong's process to estimate the organic carbon and the organic nitrogen, but this, like the other process, gives only relative results, and in the case of the River Thames it is not applicable, because sea water gives very much organic carbon and very much organic nitrogen, so that the organic matter in sea water is fouler than the sewage itself, if we take that analysis as our guide; whereas both the oxygen and the albuminoid ammonia process show the sea water to be pure.

15,996. You mean that, if you take by that process the organic carbon and the organic nitrogen as a guide to the impurity, it leads you to the result that any sea water is a very impure water?—Yes.

15,997. Because of the carbon and nitrogen in the sea water?—Yes, and the relation between the two is such as to lead you to the conclusion that it is worse than sewage. Professor Frankland himself abandoned the process, as not leading to any conclusion, therefore the processes we have adopted in all our analyses is the amount of oxygen absorbed from permanganate, and the amount of albuminoid ammonia evolved.

15,998. You believe these to be the more reliable processes?—I believe they are in this case.

15,999. You have made a large number of analyses of the water taken from all parts of the river, and you have also made an analysis, for the purpose of comparison, of ordinary London sewage, have you not?—I have.

16,000. In the first place, would you give, for the purpose of comparison, the result of the analysis of true London sewage?—The average during the year 1882 of true London sewage is that it contains 12 grains of chlorine per gallon, it yields 0·44 of albuminoid ammonia, it absorbs 2·8 grains of oxygen from permanganate, and holds about 25 grains of matter in suspension.

16,001. Analysing that suspended matter, what percentage is volatile, and what percentage is fixed?—64·5 per cent. is volatile, and 35·5 per cent. is mineral; the volatile matter contains 5·75 per cent. of nitrogen.

16,002. You have also gone carefully into the question of the amount of matter per head of population that goes into the sewers?—I have.

16,002*a*. You had better give this figure according to your own results?—Per head of population, taking a mixed population, it comes in the form of fæces to one ounce, and in the form of urine to 1·68 ounces, that is when dried at 212 degrees. Out of this 1·68 ounces, roughly speaking, half is urea, and that urea is all converted into carbonate of ammonia before it reaches the river.

16,003. Before you analysed it was your analysis made of the sewage which contained no urea?—Yes; I am giving the total solid matters which go into the river. Of the remainder, only one fifteenth is organic matter; the rest is mineral, chiefly chloride of sodium, common salt.

16,004. (*Sir John Coode.*) Are we to understand that these samples were taken at the mouth of the sewers, as the sewage fell into the reservoir?—A number of samples were dipped out of the sewers as they came from the reservoir into the river.

16,005. (*Mr. Bidder.*) But your former samples of standard London sewage were taken at an earlier stage?—What I am now giving are general figures taken from a variety of sources, not any sort of analysis.

16,006. Those are the contributions per head of population?—The samples taken at the outfall sewer contained no urea.

16,007. (*Sir John Coode.*) I want to know at what particular point the samples were taken which you say were taken from the sewers?—They were taken either out of the main reservoir, or out of the sewer which is discharging into the river. The total amount of organic matter out of the 1·68 ounces of urine solids which actually goes into the river, and pollutes the river, is only ·056 of an ounce per head. From the 1 ounce of fæces about ·14 of an ounce is also mineral matter, and I estimate that the total amount of organic matter per head of population which actually goes to pollute the river is only ·916 of an ounce per head, which,

*Dr. A. Dupré, Ph.D., F.R.S.*

19 June 1883.

taking 4,000,000 of people, comes to about 100 tons a day, or 36,500 tons a year.

16,008. There was some question of that when Professor Way was here. I do not know whether you greatly differ from him, but what would be the amount of oxygen that you would require to oxydise that?—I should say it is certainly less than 200 tons; we get therefore only 100 tons a day against the "400 tons of filth" which Dr. Tidy calculated as being discharged into the river.

16,009. (*Mr. Bidder*) I think Dr. Tidy afterwards said that there was a mistake about that; that part of that was moist. (*To the witness.*) Now, coming to your analysis upon the condition of the river, I suppose there is generally more or less turbidity all the way from Teddington to Southend?—Yes, always.

16,010. Do you find the amount of suspended matter varies very much even in the same place?—It varies very considerably even in the same place.

16,011. Whether it be up at Teddington or down below?—Yes.

16,012. What do you say from analysis as to the composition of the suspended matter in different parts of the river?—The composition of the suspended matter in different parts of the river is really very much alike, but sometimes the suspended matter is worse at the upper part of the river; actually at Teddington, for example, than it is at Crossness.

16,013. By "worse" do you mean in the sense of having a larger percentage of volatile or combustible matter?—Yes, and even in regard to nitrogen sometimes.

16,014. You have before you a table which shows the figures from places all the way down?—Yes, upon January 15th, 1878, samples were taken at many stations down the river every hour during the 24 hours, at the top, and bottom, so that at each station no less than 37 samples were taken, and they were all analysed.

16,015. You show a certain increase in grains of suspended matter per galllon, I think, as you go down the river, but with, however, considerable irregularity and fluctuation?—Yes; no definite line can be drawn, that is to say, no curve can be drawn that gives it, but the striking fact brought out in this early analysis is that the percentage of volatile matter, or matter which can be driven off, is actually higher in the upper portions of the river than it is in the lower portions.

16,016. (*Chairman.*) Is the insoluble and unvolatile matter in the sewage, that is to say, the mineral matter, as I suppose you would call it, larger in proportion to the bulk of the sewage than it is in the ordinary turbidity of the water?—No, not in actual sewage. In the sewage the mineral matter is very much less, in sewage the mineral matter is only 33 per cent., that is to say, roughly, one third.

16,017. (*Sir John Coode.*) But that will vary very much, will it not, with the rainfall?—I am speaking of the percentage in the suspended matter, not the actual amount.

16,018. (*Chairman.*) But the question I asked was whether it was less in sewage than the proportion of suspended mineral matter in the ordinary water?—It is much more in the sewage itself.

16,019. There is less water to carry away the suspended matter in the sewage than there is in ordinary river water?—

16,020. (*Mr. Bidder.*) In the sewage you have 25 grains of suspended matter to the gallon?—Yes.

16,021. In ordinary water, how many grains have you?—It varies from one to ten or twelve grains as the average.

16,022. There is not so large a vehicle for the suspended matter in the sewage then as there is in the pure water?—Certainly not.

16,023. You took similar samples, I think, in examining this suspended matter in July last year and January this year; do they show you similar results?—Yes; they show that upon the whole the suspended matter contained less volatile matter than in the earlier years.

(*The witness handed in a bound copy of his analyses. See Appendix* B Z.)

Adjourned to-morrow at half past 12 o'clock.

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# FORTY-SECOND DAY.

## Wednesday, 20th June 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

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|---|---|
| SIR JOHN COODE, Mem. Inst. C.E. | FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S. |
| COLONEL C. B. EWART, C.B., R.E. | THOMAS STEVENSON, Esq., M.D. |
| PROFESSOR WILLIAMSON, F.R.S. | JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst.C.E. |

WILLIAM POLE, Esq., F.R.S., *Secretary.*

Dr. AUGUST DUPRÉ called again; further examined by MR. BIDDER.

20 June 1883.

16,024. (*Mr. Bidder.*) My Lord, I have here the tables with regard to which Dr. Dupré gave evidence yesterday, viz. the analyses of samples of suspended matter, and the percentage of volatile or combustible matter in the suspended matter in different parts of the river in 1878 and 1882, and I would be glad that they should be put upon the notes; but I will not occupy the time of the Commission by going through them in detail now. (*The following tables were handed in.*)

SAMPLES OF WATER WERE TAKEN IN MID-STREAM, AT AT EACH PLACE EVERY HOUR DURING ONE DAY ON THE SURFACE, HALF DEPTH AND BOTTOM. EVERY FIGURE IS THEREFORE THE MEAN OF 37 ESTIMATIONS.

| Place. | Grains of suspended matter per gallon. | Percentage of volatile matter in suspended matter. |
|---|---|---|
| Teddington - - | 1·07 | 33·6 |
| Kew Bridge - - | 1·24 | 23·8 |
| Westminster Bridge - | 1·67 | 20·9 |
| London „ - | 2·96 | 31·7 |
| Greenwich - - | 4·24 | 20·2 |
| Crossness - - | 7·54 | 17·1 |
| Erith - - | 3·27 | 21·7 |
| Greenhithe - - | 4·73 | 18·1 |
| Gravesend - - | 14·24 | 14·9 |
| Yantlet Creek - - | 5·09 | 10·4 |

The mean of our results obtained between July 1882 and January 1883, is as follows :—

| Place. | Number of samples examined. | Grains of suspended matter per gallon. | Percentage of volatile matter in suspended matter. |
|---|---|---|---|
| Teddington - | 8 | 1·72 | 14·1 |
| Hammersmith - | 6 | 1·78 | 15·7 |
| Westminster Bridge | 2 | 12·99 | 17·2 |
| London „ | 2 | 5·05 | 10·7 |
| Greenwich - | 30 | 5·04 | 20·5 |
| Crossness and Jenningtree point - | 7 | 5·20 | 20·6 |
| Erith - - | 20 | 5·06 | 18·1 |
| Greenhithe - | 19 | 3·04 | 11·8 |
| Gravesend - | 4 | 6·20 | 11·4 |
| Southend - | 1 | 2·85 | 9·7 |

(*To the witness.*) I think you have analysed, and in Table B have shown in more detail the results of samples taken upon different dates in the year 1882 at different points as regards the same thing, the suspended matter, the percentage of volatile or combustible matter, the percentage of fixed matter, the percentage of nitrogen in the total snspended matter, and the percentage of nitrogen in the volatile matter ?—Yes, it gives the composition of suspended matter a little more in detail in various parts of the river.

16,025. Is there anything more to draw attention to in that table ?—Yes, it shows that the suspended matter, even in the upper part of the river, is quite as strongly nitrogenous as that in the lower portion, it illustrates strongly what I said before, that the suspended matter is nearly the same throughout the whole length of the river, and there is a similar table in the Mud Inquiry which shows exactly the same.

16,026. (*Mr. Bidder.*) That is Table P in the evidence in the former inquiry which gives similar results as regards samples taken in the year 1879 ?—Yes.

(*Table B was handed in, and was as follows.*)

B.—MATTER suspended in Thames Water.

| Description. | % of volatile matter. | % of fixed matter. | % of nitrogen in total matter, | % of nitrogen in volatile matter. |
|---|---|---|---|---|
| From settling pond at Western Pumping Station, July 17/82 - - - | 12·98 | 87·02 | ·66 | 5·08 |
| Greenwich, mid stream, 2 feet from bottom, Oct. 12/82 (half ebb) - - | 13·6 | 86·4 | ·43 | 3·16 |
| Woolwich Arsenal, mid stream, 2 feet from bottom, Oct. 16/82 (half ebb) - | 15·07 | 84·93 | ·66 | 4·37 |
| Crossness Point, mid stream, 2 feet from bottom, Oct. 18/82 (half ebb) - - | 14·97 | 85·03 | ·67 | 4·47 |
| Erith, Sept. 7, 8, 9, 10, and 11, 1882, low water (surface) - | 21·63 | 78·37 | 1·22 | 5·64 |
| Erith, Sept. 4, 7, 8, 9, 10, and 11, 1882, high water (surface) - - - | 30·5 | 69·5 | 1·59 | 5·21 |
| Off Erith Causeway, mid stream 2 feet from bottom (one hour before high water) | 14·1 | 85·9 | ·43 | 3·05 |
| Coal House Point, mid stream, surface, 1½ hours, flood, Sept. 2/82 - - - | 13·8 | 86·2 | ·35 | 2·53 |
| Lower Hope, mid stream, 4 feet from bottom, 1½ hours before low water, Sept. 2/82 | 11·8 | 88·2 | ·29 | 2·45 |

16,027. We will now go to the results of the analyses of the water with regard to the deductions as to the amount of impurity at different parts of the river at different times; and now, I think, it will be convenient if we hand in diagrams which give in a graphic form the results of these analyses ?—Perhaps I might just say a few words about the construction of my book of tables. It is a very large book, but these tables are chiefly handed in in this great number to show the basis upon which the deductions afterwards are drawn. The whole essence of the table is concentrated into a few pages at the end giving the means; and I think it will be only necessary to refer to those beginning at page 103, those are means, the rest give the basis. *Dr. A. Dupré.* 20 June 1883.

16,028. You say up to page 103 is the detail, and from 103 onwards are the mean results, summarising that mass of detail ?—Yes, the tables are arranged in chronological order, giving always the analyses made on one day and topographically giving all the analyses made at one given spot.

16,029. The first table deals with oxygen absorbed from permanganate, which, as you explained yesterday, you regard as an indication of the amount of oxidizable or polluting matter present in the water ? — That is so.

16,030. At Teddington, on your Table No. 2 B, page 103, you start with a water which absorbs about ·1 of a grain per gallon ?—If the Commission will take the diagram marked 2 B, that gives Table 2 B in a graphic form. The diagram gives the longitudinal section of the river at its proper proportion, each place is put down at its proper distance.

16,031. That diagram represents the mean of the results during the three months of July, August, and September last ?—Yes, the river at Teddington begins with a small proportion of impurity, comparatively speaking, the impurity gradually rises to about twice that quantity, and diminishes again to less than the original quantity at Southend.

16,032. Rather more than twice, to put it strictly, and a little more than twice opposite Greenwich ?—It comes down to the purity that it was at Teddington again about Northfleet or thereabouts.

16,033. Before we go further, do I understand that in your judgment that shows that, by the time you get to Coalhaven or Northfleet, the river has done its work, and has destroyed the putrescible constituents of the sewage ?—No doubt.

16,034. And the water is restored to an equal condition of purity to what it had when it entered the tidal section of the river ?—Yes.

(*Chairman.*) Of course it does not follow that all the sewage discharged into it is destroyed, because, but for that sewage having been discharged into it, by the time it got down to Coalhaven, it might have been still purer. There is a figure in the table which shows that at London Bridge it is 183, at the tunnel it has got down to 132; that is to say, the water has purified itself in its course down to the tunnel.

(*Mr. Bidder.*) If you will look at the diagrams you will find in a good many diagrams there is a very curious accession of pollution in the neighbourhood of the bridges. What the cause of that is is perhaps difficult to say, but if you look at the diagram you will see a hump ranging between Westminster and London Bridge, showing that from some cause or other, there is a very palpable increase of pollution at that part.

(*Witness.*) It is always so, and the analysis shows the same result.

(*Mr. Bidder.*) And Dr. Tidy's analyses and tables show the same thing, as I understand.

(*Sir John Coode.*) But that is not applicable, I see, to Barnes Bridge.

16,035. (*Dr. Stevenson.*) Is not the river most impure at Blackwall; it is worse than at the outfall, is it not ?—On the average it is not so; but you will find, if we go into more detail, it is so at certain stages of the tide,—at high water or low water the increase of impurity is most marked in the neigbour-

*Dr. A. Dupré.*

20 June 1883.

hood out-falls, but if you take the mean of all, this vanishes amongst the rest.

16,036. (*Mr. Bidder.*) Turning to Table 2 C. and Table 2 B., where would you separate your results into high and low-water results, will you explain them?—Table 2 C. gives the mean result for high and low water for the months of January, March and May 1882, divided into high and low, and the figures show clearly that in the upper portion of the river it is very nearly the same at high and low water; whereas in the lower part it is distinctly worse at low than at high water.

16,037. And especially so at the neighbourhood of the outfalls?—Yes.

16,038. At No. 2 D. there is another period?—Yes; that shows the mean result for July, August, and September 1882.

16,039. There you have a worse result in the upper reaches of the river at high water, and a better result in the lower reaches of the river at low water?—Yes, and also here the same thing applies, that the impurity, starting from 1, goes up to about $2\frac{1}{2}$ as the maximum, and goes down to somewhat less than 1 lower down.

16,040. (*Dr. Stevenson.*) There is a point in Diagram 2 C., to which I wish to draw your attention, and that is, that at low water the maximum impurity appears to be above the outfalls?—It is just at the northern outfall at Barking Creek. Comparing the Diagram 2 C., which gives the earlier and cooler months of the year, with 2 D., which gives the same for the warmer months, it will be found that the river is purer in the summer than it is in the earlier spring months; and I think that will be shown again if we come to the free oxygen in the water.

(*Chairman to Mr. Bidder.*) What is the effect of this evidence? As I understand, this gentleman says this: I have done my best to ascertain, and I have ascertained, that very shortly after the discharge of the sewage into the water, the water appears to dispose of it in such a way that there is no more volatile matter in the river than is shown to have been existing in it before the sewage was introduced. He says. I do not say but what the river might be purer if no sewage were introduced into it, because that which is brought over Teddington Weir or which is found above bridge possibly would have got more purified by the operation of the river, if something else had not been introduced into it. Here are my diagrams and tables, and all that sort of thing, for the purpose of justifying that statement.

(*Mr. Bidder.*) That is so.

(*Chairman.*) And is it hopeful that we should have all those papers before us and go into them in that way? If Mr. Smith denies the correctness of the conclusion, let him cross-examine upon it. I declare I am in despair when I see these papers before me.

(*Mr. Lumley Smith.*) And I declare I am in despair at the idea of having to cross-examine upon them.

(*Mr. Bidder.*) What I proposed to do was simply to draw attention to the general results which these analyses show, and then, as your Lordship suggests, leave my learned friend to cross-examine.

(*Chairman.*) That is Dr. Duprè's evidence, and it is most valuable evidence; and after we have the statement to show how he comes to the conclusion, it is in vain for us to go through each one of these tables.

(*Mr. Bidder.*) I do not propose to go into them in minute detail, but to point to the things which the witness considers these diagrams are valuable as showing.

(*Sir John Coode.*) And to the salient points only.

16,041. (*Mr. Bidder.*) That is all. I do not think your Lordship will find me trespass beyond that. (*to the Witness*). I think we now come to another class of diagrams, which deal with the matter in another point of view; that is, the quantity of oxygen absorbed?—There is one diagram, I think, which is of considerable value, before we come to the oxygen absorbed, that is, 2 F. It has been stated that the river is getting progressively fouler. Now here I have a number of analyses at a year's interval at similar places, and in Diagram 2 F. the dotted line represents the year 1882; the full line represents the year 1883; and it will be seen that upon the whole, where the analyses are coincident, the river is, if anything, perhaps a little purer in 1883 than it was in 1882.

16,042. (*Sir John Coode.*) But what about the quantity of fresh water in the river at the respective periods; it is very material to know that?—I do not think there would be very much difference between the two.

16,043. (*Sir John Coode.*) That will be a question of fact?—No doubt.

(*Mr. Bidder.*) It is subject to that observation, no doubt.

(*Witness.*) It is subject to that observation, but that is one of the points which make for my contention. The river is so frequently flushed out that it does not get progressively more foul.

16,044. (*Mr. Abernethy.*) If you refer to Diagram No. 2 C., you will see that at Vauxhall, Westminster, and Blackfriars bridges, the diagram shows as almost identical the high and low water areas as regards results?—Yes.

16,045. Now will you turn to the next diagram, 2 D., at the same bridges you will find a very great difference between the high and low water results?—Yes; no doubt there was less fresh water coming down the river at that time.

16,046. (*Mr. Bidder.*) Now I think we may pass to the next series of diagrams which deal with the albuminoid ammonia. You told the Committee yesterday that a second way of testing the amount of impurity in the water, was by the albuminoid ammonia process, the tables relating to that begin on page 108, and the diagrams commence with No. 3 B. I will ask you, generally, do the results as shown in the tables, and as shown on the diagrams which plot out the albuminoid ammonia, give similar indications to your judgment with those that you derive from analysis as to the oxygen absorbed?—Practically they are identical.

16,047. I notice, taking the first diagram, No. 3 B., which is the mean result for July, August, and September, that it shows as the other did, that starting from Teddington you get an increase of impurity as you go down the river to the outfalls, diminishing again to less than its original impurity by the time you set to Southend?—Yes, that is so.

16,048. And it also shows curiously enough that very remarkable accession of impurity in the neighbourhood of London Bridge in the city, to which you have averted?—Yes, that comes out nearly always.

16,049. (*Dr. Stevenson.*) Are those waters which have subsided?—Yes, the analyses are taken after they have subsided always. Now the next two diagrams are analogous diagrams divided into high and low water, and they give the same result.

16,050. (*Mr. Bidder.*) They give the same result, that is to say, that the river above the outfalls is purest at low water, and the river below the outfalls is purest at high water?—Yes.

16,051. (*Sir John Coode.*) With regard to diagrams 2 B. and 3 B., a note in red says "mean result," but there is no reference to the period of the tide; is that the mean of observations taken over all periods of the tide?—That is the mean of all the analyses taken at any period of the tide.

16,052. (*Mr. Bidder.*) Diagrams 3 C. and 3 D. are divided into high and low water; you have first the mean of the whole, and then you have it divided into high and low water.

(*To the witness.*) Then there is one I should like to draw attention to before we pass from that series of diagrams. There is diagram 3 F., which is of considerable interest, because it bears upon the question of whether the condition of the river is getting worse or not. You have there plotted, I think, results from

analyses in 1878, 1882, and 1883, applying the albuminoid ammonia process?—Yes, the year 1883 is throughout the best.

(*Colonel Ewart.*) According to Table 3 C., the worst place is Deptford Creek.

(*Mr. Bidder.*) At high water Deptford Creek, and at low water Greenhithe.

(*Colonel Ewart.*) At Deptford Creek there is a storm overflow.

(*Witness.*) Yes there is a storm overflow there. I believe that at high water the maximum impurity goes up the river, at low water it moves down the river.

16,053. You do not attribute it to any local cause at Deptford Creek?—No.

16,054. (*Dr. Stevenson.*) I observe that at low water the maximum impurity is at Greenhithe; do you think the low water carries it down as far as Greenhithe?—In the cooler months you find that that is so when there is less oxidation, but in the summer months the maximum is at Jenningtree Point. I think that illustrates very strikingly the amount of oxidation that goes on during the summer, which keeps down the amount of impurity compared to the cooler months of the year.

16,055. (*Mr. Bidder.*) Is it that the impurity requires more oxygen in hot weather?—No, the influence is more active.

16,056. (*Chairman.*) In regard to 3 C., why is it so high at Galleons Reach?—That is the result of only one analysis of what may have been an exceptional sample. I think it must have been an exceptional sample, but having been analysed it was thought best to put it in.

16,057. One is inclined to think, from your diagram, that you have taken samples all the way along the line of the diagram?—Only where there is a break in the line. A break in the line indicates the point where a sample has been taken, and the exact position is given in the corresponding table, which is numbered and figured the same; you will find that in table 3 C.

(*Chairman.*) It is impossible, from this diagram, to conclude that there is a gradual worsening of the water, so to speak, from Northfleet to Coalhouse Point.

(*Mr. Bidder.*) The two analyses are at Northfleet and Coalhouse Point; all you can do to cover the intervening ground is to draw a straight line.

(*Witness.*) That is a necessary consequence of having analyses drawn at a certain point; there were so many diagrams already that it would have made a great increase in the number to have done it otherwise; but you will find the two days given quite separately.

(*Chairman.*) It is a little misleading to draw a line from point to point.

(*Mr. Bidder.*) It would have been best to put dots as well, but the eye wants a connecting link between them.

(*Witness.*) If your Lordship will look at diagram 2 G., that is a single day's experiment, two samples are taken at each place and analysed, one at high and one at low water.

16,058. (*Sir John Coode.*) That is a diagram of a class which, to my mind, is more valuable than giving mean results, because here you have different parts of the river upon the same day. I think it is a safer diagram to draw a conclusion from than those which are mean results, which extended over several months in a given year, or comparing one year with another year?—But there is also a diagram which gives the highest and the lowest result at each place. Diagram 3 E. shows for every place in the river the highest and the lowest result in albuminoid ammonia during the whole time.

16,059. (*Mr. Bidder.*) The worst and the best samples you get during those months?—Yes, during the year; and there is a corresponding table on page 111. Then if the Commission will look at diagram No. 3 G., that gives the albuminoid ammonia for a single day taking it right down the river.

16,060. Now I pass from that series of diagrams to the last series, which are diagrams No. 4 B., and so on; those are, I think, drawn to deal with the matter from the third point of view you mentioned yesterday, viz., examining the amount of free oxygen remaining dissolved in the water?—Yes.

16,061. If the amount of pollution introduced into water is very minute, the absorption of the oxygen from the air would prevent any reduction in the amount of free oxygen, would it not?—It would. The oxygen would be as rapidly absorbed from the air as it would be taken up by the polluting matter.

16,062. But if you introduce polluting matter more rapidly than the air will supply oxygen, by that process, you then get a diminution of the free oxygen in the water?—Yes.

16,063. That diminution being the measure of the amount of oxidation of putrescible matter which has gone on?—In a certain way.

16,064. In these diagrams, generally, I believe, you have assumed the percentage,—that is to say, full aëration, such as you find in the water at Teddington; you put down at 100?—Yes.

16,065. And then in your diagram, according to that scale, you have indicated the percentage of the full quantity of free oxygen which you find at the different places;—Yes, which was still left in the water.

16,066. I would like to ask you one question also before we go further. Do you agree with Dr. Tidy's view, that the fact of the oxygen having fallen sensibly below the full, or what we may call the standard, amount, is an indication that the river has lost its power of oxidation?—No, I think not. I think that is an entirely erroneous view. It proves that there is a very considerable amount of oxidation going on, and that the oxidation is so rapid that the water cannot recover the oxygen necessary from the air with sufficient rapidity,—that the lower the oxygen is, the greater, really, is the amount of oxidation actually going on.

16,067. (*Chairman.*) But that is not a difference with Dr. Tidy, is it?—Yes; he says that the river would have lost its power. See Dr. Tidy's answers to Questions 9957, 9958, 9960, 9961, and 9963.

(*Chairman.*) He says that water which, has lost its oxygen to a certain extent by reason of its having oxidised certain things, has less oxygen left in it than there was before.

(*Dr. Tidy.*) I think it right to say that I never suggested anything of the kind which the witness attributes to me.

16,068. (*Chairman, to the witness.*) Let me put it this way: if he said it, he is wrong?—Yes.

16,069. (*Mr. Bidder.*) Perhaps we may have misunderstood the effect of Dr. Tidy's evidence. Now, turning to the diagram No. 4 B., you could not do this all through in one day, so you have been obliged to make up this diagram by two days analyses?—Yes, it would have been impossible to go from Teddington to Southend, and analyse the water in one day.

16,070. This is an analysis, I understand, which has to be made upon the spot?—Yes.

16,071. (*Sir John Coode.*) There is a long interval intervening between them. There is one in August, one in September, and one in November. Would it not have been better if they had been taken all in the same month?—But that November one is done for the special purpose of comparison; it shows that when the weather is cool less oxidation goes on in the river, and in consequence more oxygen remains in the water, corresponding to the fact that we found more organic matter in the water during the cooler than during the warmer months. The long curve upon the diagram is made up from the samples taken on two days only, and it will be seen on reference to Table 4A, page 66, that the degree of aeration found at Westminster Bridge (the place common to both days) on the two dates differs but slightly, viz., 54·5 per cent. on August 9 at nearly high water, as against 48·6 per cent. on September 2 at

*Dr. A. Dupré.*

20 June 1883.

three-quarter flood, thus showing that the condition of the river did not differ much on these two days.

16,072. (*Dr. Stevenson.*) I suppose that, taking the different dates, if they are reduced to a common percentage of 100, they would still exhibit the same amount of oxygen?—Yes.

16,073. (*Mr. Bidder.*) Starting, with water thoroughly aërated, at Teddington, it diminishes, until opposite the outfalls it gets to its lowest, when there is only 20 per cent. of the original oxygen, and then rises at Southend again to its original complement of oxygen?—Yes, it does. At Southend the oxygen is given only as 96 per cent., but that is not due to the fact that any oxygen has been abstracted, but that the salt water dissolves less oxygen than the river water. It is here a water thoroughly aërated, but it is only 96 per cent. of what it would be in fresh water.

16,074. (*Sir John Coode.*) Because of the proportion of salt water which is mixed with the fresh?—Yes, so that really it comes again to absolute aëration.

16,075. (*Mr. Bidder.*) The general result you draw from this is, I think, that the effect of the introduction of the sewage from the metropolis has been entirely disposed of before you get to the lower reaches of the river?—Yes.

16,076. That the river has done its work in destroying the sewage?—Yes.

(*Chairman.*) I think Mr. Dibdin scarcely said that. I think he said there was still some sewage in the water which would prevent the water being drinkable.

(*Mr. Bidder.*) I think he said he could not undertake to say it was not.

(*Witness.*) I think his analyses do not go down so far as mine do. I think he stopped at Purfleet. At Southend the water would be undrinkable, because it is sea water.

16,077. (*Mr. Bidder.*) Now, going on to the next diagram, you have taken careful and complete observation at a particular place to show the state of the water at different periods of the tide?—Yes.

16,078. And that at an important place for the purpose of this inquiry, that is to say, Erith?—I went down on two days to Erith, and took samples of water at three stations upon the river, viz., at 200 yards from the south shore, at mid-stream, and 200 yards from the north shore.

16,079. What is the general result you get from your observations at Erith as to what happens in respect to the amount of free oxygen?—Starting at low water the proportion of free oxygen is at the minimum. As the tide goes up the amount of oxygen increases, and comes to the maximum at high water, when it has risen from about eight or ten per cent. to upwards of 40 per cent., or very nearly half. It goes down again as you approach low water. The degree of aeration here, as in other parts of the river varies exactly as the oxygen absorbed from permanganate and the albuminoid ammonia yielded were found to vary, all three methods, thus mutually supporting each other.

16,080. Now I will ask you a question about the south shore diagram, which is not so regular as the other; have you any explanation to give as to the apparent irregularities in the diagram and the results there shown?—When we made the experiment, I did not know it; but it appears that the engineering evidence clearly points out that there are some eddies at Erith upon the south shore which complicate the result, and sometimes bring the middle part of the river nearer to the shore or *vice versâ*, and there is an irregularity here which is not observable in the other diagram, because there are no eddies upon the other side.

16,081. Does this comparison of the oxygen in the water at Erith at low and at high water show you that a very large quantity of oxygen is added to the water in the interval between the two states of the tide?—Yes, I think it shows that the river is here beginning to overpower the polluting influence.

16,082. So that the stream which has gone down with its contribution of sewage that it has received from the outfalls, comes back with a fresh supply of oxygen, ready to deal with the next contribution of sewage?—That is so.

16,083. I do not know whether you are able to go a step further, and make a calculation as to the amount of oxygen which comes up upon a tide?—Taking the amount of water which passes up on a tide from Mr. Mansergh's statement, and taking the oxygen from my table here, I make it that as much as 233 tons of oxygen pass up the river in one tide, or 466 tons in a day.

16,084. That is to say, that a quantity of additional oxygen goes past Erith in the water as it goes up in addition to what was in the water when it went down?—Yes.

16,085. And is therefore there for the purpose of oxidation?—It is there to deal with the sewage which would require 100 tons of it.

16,086. (*Mr. Lumley Smith.*) Do you mean that that is the absolute amount of oxygen which passes one given point down the river, or is that the excess of what goes down?—It is the absolute amount that passes Erith upon a tide, and not the excess.

(*Mr. Bidder.*) To make that clear, because it is important that it should be made clear, is it a total of 40 per cent., or is it the difference between the 40 and the 8 per cent.?

16,087. (*Dr. Stevenson.*) Is that 233 tons the total amount of oxygen in the water that passes up at every tide?—It is.

16,088. (*Mr. Bidder.*) And it is not the difference between the 8 and the 40?—No. The mean quantity dissolved in the water is about 25 per cent., and as there are estimated to be 21,000,000,000 gallons of water passing up, each gallon containing half a cubic inch, the total quantity comes to 233 tons.

16,089. Then that 233 tons is based not upon the maximum observed, but upon the mean quantity?—Yes.

16,090. And that mean is about 25 per cent.?—Yes.

16,091. If we are to calculate the difference of what goes up as compared with what goes down, that is to say, comparing the 40 per cent. with the 8 per cent., it would be a bigger figure?—No; I do not think you can calculate that; that which I have stated is the quantity of oxygen in the water into which the sewage is discharged.

16,092. If you were to form the same calculation for the lower reaches of the river, inasmuch as the quantity of water is very much larger, you would get a larger quantity of oxygen?—Yes, as much as 10,000 tons of oxygen pass Southend upon the two tides, dissolved in the water, and only about 100 tons are necessary to burn up the sewage.

16,093. I think there was a slip which Professor Way made; he said provided the oxygen in the air was required to oxidise the sewage, the air of the neighbourhood would be irrespirable. I believe your analysis does not bear that out?—No; the effect would be so small that the difference in the air would not be perceptible.

16,094. Have you anything to say about the chlorine?—No; I think that Mr. Law has gone fully into that; I would only remark that the amount of chlorine upon the 14th of September seems, according to their experiment, to have been an exceptionally high amount; we have never had anything so high.

16,095. Taking the results of all these analyses, or these three different modes of dealing with this question, what is the general conclusion that you have come to as to whether the sewage does make the river in an unwholesome state, or whether the river is sufficient to deal with it?—I think they show that the river is quite capable of dealing with the amount of sewage discharged into it, without ever getting generally into a bad condition, and they show also, clearly, that the amount of sewage daily discharged is, upon the average, daily got rid of, otherwise there would be a progressive increase in the pollution which we have not observed, and we have observations after

an interval of five years. The sewage outfalls were opened, I think, in 1865; we have the first series of analyses in 1878 and the last in 1883, so that a five years' interval is a very considerable proportion of the whole, and yet they show no progressive increase, on the contrary, as I said, 1883 is slightly the best of all the years, showing, I think clearly, that the river is quite capable of disposing of the sewage that is discharged into it.

16,096 I should like to ask you a general question. Taking Erith, for instance, and the amount of pollution at Erith which your analyses indicate, what percentage of pure sewage, let us say added to the Teddington water, would represent that?—Something like 3 to 4 per cent.

16,097. That is at low water, is it not?—Yes.

16,098. And at high water?—At high water it come to considerably less; it often is less than 1 per cent.

16,099. (*Prof. Williamson.*) May I ask you a question for my own information. I understood you to have said that the river is capable of dealing with the sewage, and I understood that it was by oxidation, and that that is shown by the fact that there is not a progressive increase. Now, if the river were a lake instead of being a river, one could quite see that so much sewage being poured in in the 24 hours, there must be a corresponding quantity of oxygen combining with it to prevent an increase; but if it passes out of the river, the increase would not take place, as it would if it were a lake. But we have to consider whether there is usually present in the river a certain quantity of unoxidised sewage materials which smell. I do not quite see at present how your arguments bear upon that. Of course the sewage could not increase if there be daily a certain quantity going out of the mouth of the river. Supposing half of it were oxidised, or supposing a quarter of it were oxidised, still itwould, after a certain time, arrive at the maximum, and keep at that?—Yes, that would be so; but the contention on the other side is that it does decidedly go on getting fouler from year to year.

16,100. Then you do not contend that it is all oxidised?—No; I think a great part of it is disposed by animal life and vegetable life.

16,101. It goes out of the mouth of the river, does it not?—No, I do not think very much goes; I think it is disposed of before it gets to Southend.

16,102. It is eaten up?—Yes; the amount of infusorial life in the river in the summer is enormous.

16,103. (*Sir John Coode.*) Was there chemical evidence upon the other side to show that the river was getting worse?—Yes, Dr. Frankland stated that distinctly.

(*Chairman.*) I think Dr. Tidy does not differ from you; he does not say that the river is getting worse.

(*Dr. Tidy.*) I did not suggest that. From season to season I said, not from year to year.

(*Witness.*) I think you will find that Dr. Frankland said that it was getting worse progressively.

16,104. (*Mr. Bidder to the witness.*) Now you, in the course of making your analyses and taking samples, have been on the river upon many occasions, have you not?—I have been upon the river upon many occasions.

16,105. And especially with regard to the subject of this inquiry?—I have.

16,106. For instance last year, I think I may say, you were down the river a good many days?—I was 17 days upon the river in the summer during the months of July, August, and September.

16,107. Could you upon those occasions perceive any offensive or disagreeable smell proceeding from the water, excepting in the immediate neighbourhood of the outfalls?—No. We had always a large bottle with us and took samples repeatedly going up and down the river, shaking up the bottle to smell the water. And I repeatedly got into the small boat to get into the spray of the screw of the steamer, but outside the sewage stream I never smelt the river in any way to be offensive. The smell is very much the same really from Teddington downwards, it is a peculiar musty odour like wet straw; it is very faint and only perceptible when it is shaken up as I have described.

(*Sir John Coode.*) Were any of your samples taken after the "Princess Alice" disaster, when the river was stated to have been in an exceptionally bad condition.

(*Mr. Bidder.*) No. Mr. Dibdin's samples were, I think.

(*Mr. Lumley Smith.*) They were taken, I think, some time afterwards.

(*Mr. Bidder.*) We had some samples taken within either two or three weeks of the time.

(*Mr. Lumley Smith.*) They will be found on page 21 of Mr. Dibdin's table taken on the 24th of September.

(*Witness.*) My nearest time, I think, was in November of the same year. I was not upon the river earlier than that.

(*Mr. Bidder.*) I might mention, though we have not given it in evidence, but Mr. Dibdin tells me that what was called the "Lancet" Commission published a series of analyses taken immediately after the accident which give identically or substantially the same results as those which Dr. Dibdin gives, Nos 5 and 6 were taken at Beckton, and Nos 7 and 8 were taken at the place of the "Princess Alice" accident, by Dr. Dibdin.

(*Witness.*) I have frequently been down afterwards and examined the water at the spot where the "Princess Alice" went down, and I never found it offensive.

16,108. (*Mr. Bidder.*) Have you been there in hot weather in the summer?—I have been there in hot weather in the summer. I was there last year several times in the hottest part of the year.

16,109. You have been in the stream of the sewage itself, have you not?—Yes.

16,110. What do you find there?—The actual stream of the sewage in hot weather is very offensive and very nauseating, but it is not a very powerful or penetrating smell, so that it is very soon lost; and even if you go down in the actual sewage stream in ordinary weather, you lost the smell of the water in about 1,000 yards; you do not even smell it then, even if you shake up the bottle, but you lose it in the river in a boat within a few hundred yards. I was down there last Saturday, and I have never seen the sewage stream so well defined as it was on that day. At 2,000 yards down the stream you could see you were in the sewage stream because of the floating matter; you could not see the sewage, but only the floating matter.

16,111. (*Chairman.*) What is it you smell, is it a gas?—I think it is an actual gas, carburetted hydrogen, or something of the kind, which is given off.

16,112. (*Mr. Bidder.*) But there is something more than carburetted hydrogen in that fœtid smell, is there not?—I think that is the chief, but some compound ammonias are given off. It is a very complex mixture; but even on Saturday at 2,000 yards, as I was saying, the smell in the water was gone.

16,113. (*Prof. Williamson.*) Do we understand you rightly to say that at 2,000 yards from the outfall the sewage stream which you can see does not smell?—You can see that the sewage stream is passing there by the amount of floating matter in the water; you do not see the actual sewage passing down, but you see small pieces of cork and vegetable matter, and even small pieces of excrement.

16,114. One witness stated that he could trace the line of demarcation between the sewage water and the rest of the river for some way down, as if the sewage did not mix; what do you say to that?—I have never seen that beyond 500 or 600 yards.

(*Mr. Bidder.*) There is no dispute that for a certain distance you can see the sewage.

16,115. (*Prof. Williamson.*) We were told that a boat was moored so as to be half in and half out of the sewage stream?—Yes, you can do that when you are 200 yards off the outfall, when it is very distinct

*Dr. A. Dupré.*

20 June 1883.

indeed; but at the northern outfall you lose that when the stream from Barking Creek comes in and pushes it out further into the centre of the river.

16,116. (*Chairman.*) Do you smell it at the Reservoir?—Yes, but it is so faint a smell that at 200 or 300 yards off, even if the wind is blowing towards you, you lose the smell. It is a nauseating smell when you are in it, but it is not a penetrating smell, it is not carried to any distance.

16,117. (*Mr. Bidder.*) Do your general observations as well as analyses confirm you in the view that within a few hundred yards the sewage very rapidly mixes with the general body of the river water?—It mixes very rapidly indeed. The great rapidity with which the sewage mixes with the water comes out very strongly in Dr. Tidy's Table No. 6, in which there are a number of analyses of sewage taken at the Crossness Outfall; they were taken at the outfall while the sewage was discharging, and the amount of organic carbon is scarcely ever much higher than it is in the river itself, showing how very rapidly, even at the outfall, the mixture takes place.

16,118. (*Sir John Coode.*) You mean in the filtered liquid?—Yes.

16,119. (*Mr. Bidder.*) I must ask you to go back to another matter. Have you observed upon that part of the river, from the neighbourhood of the outfalls down towards Erith, often very distinct and offensive smells which might reasonably give rise to the complaints of people who think they smell the river?—Yes; one notices a great many excessively offensive smells from the factories.

16,120. Have you found these factory smells, according to your observations, more or less penetrating in the sense of reaching a distance than sewage smell?—They are very much more penetrating; you can smell them sometimes 2,000 or 3,000 yards off powerfully, so as to be offensive.

16,121. And besides that I think there is a good deal of material carried in boats on the river of a very offensive character?—There is a very great deal of slaughter-house refuse and manure, and various offensive matters, rotten fish for making the manure, for instance, and the smell from those is sometimes really almost indescribably offensive.

16,122. I must ask you just to deal with another topic of discussion. There have been a good number of witnesses here, unscientific persons, who have asserted that the mud in various places is little more than deposited sewage, and is quite different from ordinary river mud. You have analysed the mud upon a great many occasions, have you not?—I have.

16,123. Both for the last inquiry and since?—Yes.

16,124. What is the result of your analysis of the mud at Erith and the neighbourhood up and down the banks of the river as showing whether it is or is not ordinary river mud?—The result is that all along the river, from Teddington downwards, the mud, wherever there is mud, is very much the same. If there is a differencee the mud of the upper part of the river is slightly fouler than that of the lower portion of the river; for example, almost the worst bank in the whole river is at Westminster, which is very bad.

16,125. (*Sir John Coode.*) On which side of the river at Westminster is that bank?—It is below the Houses of Parliament.

16,126. (*Dr. de Chaumont.*) Do you agree with the opinion of Dr. Frankland, that the river is getting progressively fouler now above the outfall within London itself?—Decidedly not; all my evidence goes the other way.

16,127. Dr. Frankland says at question 10,686, "After the opening of the outfalls the river remarkably improved in purity; but since that time, from soon after the main drainage outfalls were opened, the purity of the river in London has been decreasing" Do you agree with that?—No, I do not. That was the answer I was referring to when I gave my evidence just now.

16,128. (*Sir John Coode.*) How far below the Houses of Parliament is this bank you spoke of just now?—It runs along the Houses of Parliament from Westminster Bridge upwards. I do not know how far it extends.

16,129. Do you know anything of a bank under St. Thomas's Hospital which used to accrete very rapidly?—Yes, I have analysed that too.

16,130. I have heard the late Mr. Leech, the engineer to the Thames Conservancy, speak of that bank as a difficulty; was that a nuisance?—I would not say that, but chemically it was very bad. I have not been on the bank when it was exposed.

16,131. (*Chairman.*) I suppose you would say it would not be smelt from the hospital?—I never heard that they complained about it in the hospital.

16,132. (*Mr. Bidder.*) I believe you wish to hand in a table with respect to this mud bank at Erith?—Yes, I beg to hand in Table C.

*The table being handed in, was as follows:*

C.—Samples of Mud from Bank at Erith.

| Description. | Percentage of Volatile Matter. | Percentage of Fixed Matter. | Percentage of Nitrogen in Mud. | Percentage of Nitrogen in Volatile Matter. |
|---|---|---|---|---|
| Pier, December 22, 1878 (surface) | 11·96 | 88·04 | ·44 | 3·68 |
| Causeway, August 5, 1882, near water line, one-third flood (surface) | 15·03 | 84·97 | ·59 | 3·92 |
| Causeway, August 5, 1882, near water line, one-third flood (six inches deep) | 16·63 | 83·37 | ·62 | 3·72 |
| Causeway, August 31, 1882, low-water line, very low water (surface) | 8·08 | 91·92 | ·24 | 2·97 |
| Near Balast Wharf, August 31, 1882 (surface) | 9·16 | 91·84 | ·23 | 2·57 |
| Halfway between pier and Easton and Anderson's low-water line, December 18, 1882 (surface) | 12·88 | 87·12 | ·36 | 2·79 |
| Halfway between causeway and pier, low-water line, December 18, 1882 (surface) | 12·00 | 88·00 | ·51 | 4·17 |

16,133. (*Mr. Bidder.*) This all relates to Erith?—Yes, because the other banks have been so often analysed that I took this to show that the bank at Erith does not differ in any way from the banks in other parts of the river.

16,134. When you refer to other analyses you are speaking of the analyses in the Mud Inquiry?—Yes.

16,135. Does the analysis of the Erith bank show it to be practically of an identical composition with the mud banks up and down the river, as analysed by you upon the former occasion?—It does, decidedly.

16,136. (*Chairman.*) You limit it to the bank at Erith?—Yes.

16,137. Those are the samples you took, and you know otherwise of the composition of the mud at other parts of the Thames, and you say those correspond?—Yes.

(*Mr. Bidder.*) After page 1065 of the Mud Inquiry, there is a series of tables, and, perhaps, the best one of all is Table U.

(*Witness.*) Yes, that gives the proportion of nitrogen, which is the important thing, and that compares with the last figure in this Table C.

16,138. That table is arranged by progressive pollution without regard to locality, and a glance at the places show that the amount of pollution is quite irrespective of the part of the river; indeed, a good number of the worst are up at the higher part of the river?—Yes, the greater number of the bad ones are up at the upper part of the river.

(*Mr. Bidder.*) Now there is one question which perhaps my learned friend could answer, which would save a great deal of time. Of course, strictly, all this mass of samples ought to be proved; but it would be absurd to keep the Commission here while they are proved in detail; and I should be glad if my learned friends would say whether they are content with them as they stand, or wish them to be proved.

(*Chairman.*) If Mr. Lumley Smith would say he is

content, I should be glad; if he does not I am inclined to say we are. There can be no doubt, for my own part, I would not admit a doubt,—as to the bonâ fides of either party in this matter—they are both public bodies.

(*Mr. Lumley Smith.*) There are one or two samples in 1878 about which one would like to know a little more, because there is a little uncertainty as to what they were; but I say, taking the samples as they stand, no doubt it is impossible to prove all these samples.

(*Mr. Bidder*) Then perhaps it may be taken that unless there is anything that my learned friend wants particularly to draw attention to, the samples need not be verified.

(*Mr. Lumley Smith.*)—Yes.

Cross-examined by Mr. Lumley Smith.

16,139. First of all, I want to ask you a general question or two about these processes. It was suggested by Dr. Dibdin that Wanklyn's method was not to be depended upon—what is your opinion as to that?—I think, when properly performed, it is fairly reliable.

16,140. Which do you consider the more reliable, the Wanklyn or the oxygen process?—My experience is, that if they are both worked well, they give, as a rule, analogous results. I really would not like to say which was the most reliable—in certain cases, one might be the better, and in other cases the other might be the better.

16,141. You have given in your tables the result of your oxygen test, and the result of your albuminoid ammonia test?—Yes.

16,142. Is it not the fact very often, that in the same place you find different results—it is not a rule of three sum. Supposing you compare water at different places, the amount of oxygen which one requires does not show the same amount of impurity by the oxygen test, as would be shown comparing the two places by the ammonia test, does it?—Not always, strictly speaking; but, broadly speaking, they do show the same result.

16,143. If you turn to page 59 of your book, you will find a couple of samples which have pretty nearly the same amount of albuminoid ammonia, that is to say, No. 386, in which the albuminoid ammonia is ·036. Now, if you go a little way back to No. 382, you will find the albuminoid ammonia is ·038, so that judging by that test, they are pretty nearly equally bad or equally good?—Yes, that is so.

16,144. Now we will go to page 33, and compare the amount of oxygen which those two samples take—No. 386 takes ·314?—Yes.

16,145. And if you refer to No. 389, you will find it takes ·118?—That is so.

16,146. So that, although these waters are pretty nearly equal, as shown by the albuminoid ammonia process, when you come to test them by oxygen, one is not so bad as the other; and the worst according to the albuminoid ammonia comes out the best when tested by the oxygen process—is not that so?—The three quarter ebb is, in regard to oxygen absorbed, the worst, and in the albuminoid ammonia test the high water is a trifle the worst.

16,147. The difference is very considerable, if you take the oxygen test, and very inconsiderable if you take the albuminoid ammonia test?—Yes, that is so; but if you take the series, you will find that they follow very much the same order.

16,148. Will you turn to page 50, and look at Teddington — sample 463 — that shows albuminoid ammonia ·0269?—Yes.

16,149. Then will you turn to page 25, and, I think, you will find the amount of oxygen required by that sample is ·325, is it not?—Yes.

16,150. Now, if you will pass on to another figure, if you will go to page 59 and take Erith, No. 389, you will find there the albuminoid ammonia is ·038, that is so, is it not?—Yes, that is the same.

16,151. Then, if you turn back to the oxygen test for that sample, at page 33, you will find ·118?—Yes.

16,152. Is not the result of that this, that the Teddington sample, which had the smaller amount of albuminoid ammonia, required three times as much oxygen to oxide it as was the case in the Erith sample?—Not quite three times.

(*Chairman.*) Will you allow me to ask you, does that show anything more than that there was a mistake in the experiment?

(*Witness.*) No, I think not.

(*Mr. Lumley Smith.*) We dispute the Wanklyn process as being one to be relied upon. We also dispute to a certain extent the oxygen process as being good; and here you find that if you take two figures at random, they give opposite results.

(*Chairman.*) You have taken two specimens.

(*Mr. Lumley Smith.*) And, no doubt, we could produce more.

(*Chairman.*) But in a general way they tally, do they not?

(*Witness.*) The explanation is very simple. The two processes, neither of them profess to give the absolute amount of organic matter—they must be compared with themselves, and not one with the other. You must not compare the result by the oxygen process of different kinds of matter with the albuminoid ammonia process, otherwise you will get discordant results; but you must compare the oxygen process right through and see what you get, and then compare the albuminoid ammonia process right through and see what you get from them all, and you will then find the conclusions identical.

(*Mr. Lumley Smith.*) But I showed you that the albuminoid ammonia showed the two waters to be very much alike, whereas the oxygen process showed them to be very different.

(*Chairman.*) It may be an error of manipulation.

(*Prof. Williamson.*) I think the discrepancy of the figures can hardly be said to be a mistake in either case, because each process determines something different from the other. They each attack the question from a special side, and the quantity of organic matter can only be judged by a sort of guess work. Each determination may be perfectly correctly made within very narrow limits of accuracy, and yet they may differ from each other so that each of them gives rather a sort of approximation to the truth than an accurate result.

(*Dr. de Chaumont.*) Would it not also indicate that the kind of organic matter was different in the two cases?

(*Witness.*) No doubt it was more animal matter in one case and vegetable matter in the other case.

16,153. (*Dr. Stevenson.*) Do you know any process which gives anything more than a guess?—I do not know any process which gives more than a guess.

16,154. (*Mr. Lumley Smith.*) If this is nothing more than material for guessing at the truth, I do not know that I need carry it much further. (*To the witness.*) Are the diagrams you put in to-day based upon a single or upon a number of samples?—They are based in a general way upon a number of samples.

16,155 Upon what number in a general way?—In some cases from 20 down to three, and in a few cases upon only one.

16,156. Does that appear upon a diagram?—No, but it appears upon the tables—you can easily find it out in the tables.

16,157. The table is a catalogue of all your samples?—The table is a catalogue of every sample taken.

16,158. Supposing you had a point shown upon your diagram at Erith, or elsewhere, as the case may be, do you mean to say that by working through the tables you can find out how many samples were taken at Erith?—Yes.

16,159. It is the mean of the calculations, is it?—Yes, it is.

*Dr. A. Dupré.*
20 June 1883.

16,160. And you have not shown upon your diagram at any particular point of what number of samples it was the mean?—That is not shown.

16,161. That would make a material difference, would it not, the samples vary considerably at different places and different times?—Yes, but the table clearly shows that if you turn to the analysis showing a sample at any particular place, or if you turn to the diagram showing the highest and lowest results, that will show you at once how much they differ at any particular place.

16,162. Are all your highest and lowest together?—Yes, they begin on page 50; they are arranged topographically; you have all taken at one place, given together.

16,163. Am I to take it that upon your diagram where you have more than one sample, you have universally taken the mean?—Yes.

16,164. You have one diagram here which is called No. 4 C, which shows the percentage of the free oxygen dissolved in the Thames water off Erith pier?—Yes; they are all given on page 68.

16,165. Your diagram does not state the year in which those two were taken?—That is so; they were taken on August 31st and September 1st 1882.

16,166. You have taken these two consecutive days for what purpose?—Because I wanted to get a clear picture of the variation in the amount of oxygen.

16,167. In two consecutive days?—There is a limit to one's time. I should have liked to have had more than two; but I could not.

16,168. You think that is a fair sample?—Yes; I think it a very fair specimen.

16,169. Do not you know that Mr. Dibdin's in taking these two consecutive days founded a diagram upon the fact that there had been very heavy rain, and that it had scoured out the river, and that diagram No. 4 of Mr. Dibdin's shows that it had been a very exceptional state of things?—I think this diagram confirms that, because you will see that on August 3d it was a high tide, and that in every case the high water comes to a better figure of oxygen.

16,170. But I am pointing out that if you are taking these as an ordinary sample of the Thames, you have selected a very exceptional time, because Mr. Dibdin stated he took these samples at a very exceptional time?—First of all, let me say, there was no selection in the matter; we went down the river because we happened to have leisure upon those two days. I made no selection whatever, for I did not know that there would be a high tide upon those days.

16,171. It so happens at all events that that was a day upon which there was an exceptionally high tide which scoured out the river?—Yes, no doubt, August 31st was.

16,172. According to Dr. Dibdin's diagram, there was about the same amount of chlorine on the two consecutive days; but the amount of albuminoid ammonia varied very much?—I do not think they did vary very much. I think if you turn to the other analyses you will not find that they were especially good days; on the contrary, they were rather bad days, both of them.

16,173. Before I pass from that, I think you stated that sea water would not dissolve much oxygen?—It will not dissolve so much as fresh water.

16,174. What samples did you take of sea water; the only one which I can find is at page 64 of your book, and there I find that at Southend at nearly low water you found 96 parts of oxygen, whereas 100 is your fully saturated quantity in water?—In fresh water.

16,175. You take fresh water, when saturated, as being 100, and here I find at Southend Pier it is 96, which is nearly 100?—It is nearly 100, but it is not quite; it is so much less, because sea water dissolves less than fresh water. I took that identical sample to the laboratory, and estimated how much oxygen I could add to it, and I found that it was 95 in the laboratory which is within the limits of experimental error.

16,176. Have you any samples of pure sea water?—I have this identical Southend sample which I took home to the Laboratory, and ærated.

(*Chairman to Mr. Lumley Smith.*) Has anybody said that sea water does take as much oxygen as fresh water?

(*Mr. Lumley Smith.*) We put in some figures showing the amount of oxygen that was to be found in the sea water.

(*Chairman.*) Is it different from what Dr. Dupré says?

(*Witness.*) You do not get so much, but very nearly the same in the sea as the fresh water.

(*Chairman to Mr. Lumley Smith.*) Supposing we should agree with Dr. Duprè instead of agreeing with your figures, would it make any difference in the decision we should come to, do you think.

(*Mr. Lumley Smith.*) Perhaps not; but I think an argument was based upon it in this way,—that where there was a certain quantity of oxygen in the river, as sea water takes very little oxygen, it was said that they had the right to assume that the rest of the oxygen was consumed in burning up the sewage. Now, as sea water does take the oxygen, it may have gone into the sea water and not into the sewage.

16,177. (*Dr. Stevenson to the witness.*) Do saline solutions generally take up as much oxygen as fresh water?—No, they do not. And I may say that this is an actual experiment, whereas the figures upon the other side cannot be controlled, because unfortunately there is never a temperature given; but in my tables the temperature is always given. The amount of oxygen in water varies greatly with the temperature, and you can draw no conclusion unless the temperature of the water is given.

16,178. (*Sir John Coode.*) Four per cent. is the margin of difference between the two?—Yes; that is about it.

16,179. (*Mr. Lumley Smith.*) Now I will ask you about the quantity of matter that goes into the water. I am not going into the dry matter and the wet matter, and so on, but I want to know whose experiments you based your conclusions upon?—I took Professor Way as the authority for the one ounce in the fœces, and I think that is a very fair allowance.

16,180. There is no contention about that, that the dry matter of fœces is one ounce; but now you say that of that, about ·14 is mineral, and ·86 is organic; that you gave us yesterday?—Yes, it is so; but it varies.

16,181. Now in calculating the amount that goes into the river, you seem to me to omit the mineral part; that all goes into the river, as well as the organic, does it not?—But I only stated that which was the polluting matter; common salt will not be treated as a polluting matter.

16,182. It does go into the river; but you consider that we ought only to trouble ourselves with the organic part which you make ·86?—Yes.

16,183. (*Chairman.*) That you say is burnt up?—Yes, it is.

16,184. Reduced to its constituent gases?—Yes, chiefly to carbonic acid, nitrogen, and ammonia.

16,185. And would escape?—Yes.

16,186. (*Mr. Lumley Smith.*) Do you know Mr. Simon's book on Animal Chemistry?—I cannot say that I know it.

16,187. I see at page 372 of the edition of 1846, he gives analyses of human fœces according to Berzelius, and I want to point out to you that he makes the salts as being 12 parts out of 267?—You will find it given in some cases up to 15 and 20 per cent: it varies very largely.

16,188. He makes the minerals more than you do, and the organic matter more?—Yes, but the difference would be a mere fraction.

16,189. (*Sir John Coode.*) The organic matter is all that you thought necessary, at any rate?—Yes.

16,190. (*Mr. Lumley Smith.*) Now we will come to the urine, upon which there is a larger difference

between you. There was a great discussion in Dr. Tidy's evidence (I will not go through it all over again, but it begins at question 10,440) as to the amount of urine which ought to be taken per person, as to whether it should be taken at 40 or 60 ounces, how many ounces have you taken?—I never calculated it out into the quantity of urine per head of the population, but only the solids per head.

16,191. You gave us 1·68 as solid matter coming from the urine, now will you tell me from whose book you got that 1·68?—I think it is taken from Woolf and Lehmann.

16,192. Mr. Bidder told us, and I think it appears in the evidence, that Röder and Eickhorn took their figures from Woolf and Lehmann?—Yes.

16,193. So that Woolf and Lehmann are the foundation of the inquiry?—Yes; I have looked through a number of authorities, and I will not be sure, but I believe it is mostly if not entirely based upon Woolf and Lehmann. I have here "Liebig's Agricultural Chemistry," and I suppose I cannot well quote any higher authority on such matters than he. Now Liebig gives the total amount of what he calls the "dust-dry" residue of the liquid and solid excrement of one million people, men, women, and children, as 45,000,000 lbs. per year, which is somewhat less than two ounces per day.

16,194. Will you give me the reference to Liebig's book, because I do not want to discuss it here?—(*The book was handed to the learned counsel.*) He has given it at 2 ounces, whereas I have taken it at 2·6 ounces, which is materially higher.

16,195. You cannot tell me, however, what the quanity of urine is based upon per day?—No, I cannot.

16,196. The page of the German edition (Brunswick, 1865) of Liebig's book that you have quoted is 292?—Yes; I think it is the latest edition that was published under Liebig's supervision.

16,197. Now, with regard to this theory of yours about the river every day burning up the sewage, that is based, as I understand, upon a comparison of the free oxygen one day with another, putting out of account all displacement and all mixing?—No, it is based upon analyses five years apart.

16,198. That is based upon your 1878 samples?—Yes, and upon the 1882 samples, and upon the 1883 samples.

16,199. But it is merely done by comparing the quantity of oxygen that is found in the water upon one day with that found on the next, is it not?—No; it is based upon the fact of the impurity found in 1878, 1882, and 1883, and I find that the water in 1883 is purer than in either of the two preceding years.

16,200. Tested, in the way you have done it, by the amount of albuminoid ammonia?—And by the amount of oxygen absorbed in the two years.

16,201. (*Sir John Coode.*) To judge fairly of that, I think we ought to have some idea of the amount of water in the river, because the year 1882 was a wet year?—No, I think 1882 was not an exceptionally wet year.

16,202. I think there are no oxygen experiments in 1882?—Yes, they are all in 1882. Now I do remember something of the weather in 1878. There are two days when I was going the greater part of the way down the river, and in January, a short time before I went, there had been very heavy rain—a flood, in consequence of which the river was upon that day decidedly better; but upon March 4th, there had not been any rain for some time previously, and the river was not in flood at all.

Cross-examined by Mr. Beaumont Morice.

16,203. Upon your diagram 3 C., you show that the river was in its worst state down at Northfleet; it gets very low down there?—If you go to Northfleet it is very considerably better; I think you must be referring to Greenhithe.

16,204. Do you know how far the sewage goes down the river upon an ebb tide?—That is to say, I suppose, the water into which the sewage is discharged; it goes down about 12 miles, I believe.

16,205. From your investigations could you say whether there is any sewage at low water below Greenhithe?—I should say a very small proportion.

(*Chairman to Mr. Beaumont Morice.*) What do you mean by that: undiluted sewage?

(*Mr. Beaumont Morice.*) No, sewage still remaining, going down the river upon the ebb tide.

(*Chairman.*) Of course it is going down the river; whatever comes out of the outfalls must go down the river; but do you mean in an undiluted condition?

(*Mr. Beaumont Morice.*) No, still in the water.

(*Chairman.*) I do not understand you; it goes down the river until it gets out of the river.

(*Mr. Beaumont Morice.*) I mean, so that you can detect it.

(*Witness.*) At Purfleet you can detect it, but not by any smell, there is not the slightest smell there.

(*Mr. Beaumont Morice.*) I ask you, can you detect the sewage in the water at Greenhithe at low water in such a state as to be injurious?

16,206. (*Chairman.*) Is the river in such a state that you can detect the sewage in it?—I think you can detect it by taking the contrast between high and low water, you can see that the water at high water is still purer; but otherwise, than by analysis, you cannot detect it.

16,207. If you smell it, can you detect it?—No.

16,208. If you take it up in a bottle and shake it can you detect it?—No.

16,209. What must you do in order to detect it?—You must analyse it very carefully.

16,210. What would you find upon analysis?—You would find a little more albuminoid ammonia, and you would find that it absorbed more oxygen from the permanganate than it would otherwise.

16,211. So the volatile matter has not been destroyed entirely by the action of the oxygen in the water?—Not entirely.

16,212. (*Mr. Beaumont Morice.*) You state that you do not consider that the river is increasing in its pollution as as far you have observed?—I have observed it from Teddington to Southend.

16,213. Do you speak chemically, or from ordinary observation?—I speak both from chemical experiment and from ordinary observation.

16,214. How far does that extend, all the way down the river?—Yes, all the way down the river. It naturally fluctuates sometimes from week to week, but taking one year with the other, there is no variation.

16,215. I understand you noticed it often last year, in 1882?—I have been often on the river.

16,216. But last year was an exceptionally unfavourable year for the river, was it not, as it was cold and wet?—I do not think so. If you take the Astronomer Royal's Tables, I think you will find that the temperature was within a tenth of a degree or so of the average, and the rainfall was very little beyond that of an average year.

16,217. But have your observations extended over a series of years—eight or ten years running?—No, not running.

16,218. You stated that you went close down to the sewage?—I did.

16,219. Could you distinguish between that smell and the factory smell?—Yes, if you are close to the sewage.

16,220. You can distinguish between the sewage and the factory smells?—Yes, you can do it, but only when you are close to or in the sewage.

*Dr. A. Dupré,*

20 June 1883.

Re-examined by Mr. Norman Bazalgette.

16,221. I want to ask you whether the samples, from which you draw your annual mean, are fair average samples, or whether they are taken on any particular day or any particular month?—They were taken at random.

16,222. So that the results are not likely to be affected by any exceptional circumstances applying to a particular day?—No, I do not think they would be.

Examined by the Commission.

16,223. (*Chairman.*) I understand you say that the sewage in the river brings down with it matter which is mineral, or, I suppose, insoluble, and not to be dissipated in some way or other, and matter which is capable of being resolved into gases and escaping and being innocuous?—Yes.

16,224. I understand you to say the water has the property of acting upon the sewage brought down in such a way that it does resolve a large portion of it into its constituent gases, which are dissipated and do no harm?—Yes, that is so.

16,225. Then as to the solid mineral matter, Dr. Dibdin tells us it was mainly salt?—Yes, it was mainly salt.

16,226. What would that do?—It would be dissolved in the water; but it would be a mere minute fraction compared to the salt which came in from the sea.

16,227. You say the effect of that is that although the water smells very badly when it is stationary in the reservoir, and when it is poured out into the river, yet that at a distance of 1,000 yards no smell is perceptible, and that at a distance of, say, 10 miles, at Northfleet or Greenhithe, you could only detect that sewage had been poured into the river by analysis; is that what you say?—It is.

(*Chairman.*) I would like to ask Dr. Tidy whether he assents to the evidence you have given. (*To Dr. Tidy*) Do you differ from that?

(*Dr. Tidy.*) Somewhat, my Lord.

(*Chairman.*) That is to say, you would make out that the oxygen had more work to do, or that there was less of it to do the work, and that the smell continued longer.

(*Dr. Tidy.*) That you could smell it at a much greater distance—a very much greater distance.

(*Chairman.*) I think we may say that the difference between the distinguished gentlemen who have been called on the one side and on the other, is what you may call quantitative and not qualitative, more than anything else.

(*Sir John Coode.*) It is a question of degree.

(*The Witness.*) I would say, I believe that if you blindfolded any person, and took him down the river, he could point out to you every foul factory to the windward and every foul boat he passed by his nose, but he would not know when he passed the outfalls.

16,228. (*Chairman.*) You say you have analysed the mud, and it is not worse in the neighbourhood of the outfalls than what you call the average mud of the river?—I do.

The witness withdrew.

(*Chairman to Dr. Tidy.*) Having heard that statement, do you differ from it?

(*Dr. Tidy.*) I entirely differ from it.

(*Chairman.*) Do you say there is much more sewage in it than Dr. Dupré makes out.

(*Dr. Tidy.*) Very much more.

(*Chairman.*) More mineral constituents.

(*Dr. Tidy.*) No. I refer to nitrogenised matter which has not been oxydised, and which can undergo putrefactive decomposition.

(*Chairman.*) Which is undergoing that upon the mud.

(*Dr. Tidy.*) Which may undergo it.

(*Chairman.*) Which, as it is exposed upon the mud, gets oxidised.

(*Dr. Tidy.*) It undergoes decomposition, is not oxidised. With regard to putrefaction that is not oxidation. When we have oxidation we have harmless inoffensive bodies formed; when we have a body putrefying, we have it broken up, and offensive gases given off. In the case of oxidation, the hydrogen becomes water and the carbon becomes carbonic acid.

(*Chairman.*) One knows that rust is oxidation.

(*Dr Tidy.*) Yes.

(*Chairman.*) There is nothing foul in that.

(*Dr. Tidy.*) No, not in that case.

(*Chairman.*) Does not the organic matter get oxidised in the mud.

(*Dr. Tidy.*) Very likely a small quantity does, but its tendency is to break up and decompose into other products.

(*Chairman.*) Then you ought to smell it.

(*Dr. Tidy.*) Decidedly.

(*Chairman.*) Then all you have got to do is to smell some of this mud.

(*Dr. Tidy.*) Not necessarily; you may not smell it at the moment, but after a time it will smell.

(*Mr. Lumley Smith.*) There was some evidence as to the mud which, though it might not smell at the time, yet after two or three days it would smell.

(*Dr. Tidy.*) It would.

(*Sir John Coode.*) Is the process of oxidation ever going on simultaneously with the process of putrefaction.

(*Dr. Tidy.*) It might.

(*Sir John Coode.*) I should have thought the oxidation was always going on in a degree.

(*Dr. Tidy.*) I should think in the case of mud exposed, the tendency would be to putrefaction rather than to oxidation.

(*Sir John Coode.*) No doubt, but my question is, While putrefaction is going on does oxidation go on to any extent, or does the putrefaction go on for a certain stage, and then oxidation begins?

(*Dr. Tidy.*) I think it is quite possible for them both to go on together, but not upon the same particles.

Sir Frederick Abel, C.B., F.R.S., called in and examined.

*Sir F. Abel, C.B., F.R.S.*

16,229. (*Chairman.*) While we are upon this point, do you mind telling us what is putrefaction?—It is what chemists call a "metamorphosis," a change in the arrangement of the components of a chemical compound of animal origin containing nitrogen, resulting in the production of a class of comparatively simple bodies, some of which have very powerful odours indeed, and those produce what we know as putrifying smells or odours. Those bodies are transient in their character, and are eventually converted into the most simple products, which are, generally speaking, gaseous, and escape into the air in the ordinary course.

16,230. When they talk of burning up by oxygen, that is a sort of addition of oxygen, oxygen is added, but in putrefaction is there no addition?—No, there is no addition to the substance, it is a transformation which takes place under conditions of temperature, and other conditions favourable to that change.

Examined by Mr. Norman Bazalgette.



16,231. Before taking you through your proof, I believe you have had before you samples of mud which have been taken from the river and been placed in the laboratory?—I have.

16,232. After having been placed in the laboratory, did you find that they became putrescent and then emitted an unpleasant smell?—That is so.

16,233. Is that a characteristic of Thames mud or of all muds?—That is characteristic of any mud which contains vegetable matter.

16,234. (*Chairman.*) Or animal matter?—Yes, or animal matter, but that is comparitively rare in muds; so I did not specify it.

16,235. (*Mr. Norman Bazalgette.*) I believe that the analytical results which Dr. Dupré put in in the form of tables have been the joint work of yourself and him?—Yes, they were.

16,236. Do you agree in the general conclusions which have been drawn from them by Dr. Dupré?—In a general way, I do.

16,237. Do you agree with the chemical methods that have been employed by Dr. Dupré to get to his determinations?—I agree with the views expressed by Dr. Dupré with regard to the value of these methods. I may perhaps state shortly, as has been already stated in evidence, that we have no quantitative method for determining the actual amount of organic matter in muds. We have different methods, which have been from time to time developed and extensively used, by which we get results which give us indications of the relative degree of purity of a sample of water when examined by that particular method, there is no single method that gives us more than that. By taking the methods together, and considering the results which each individually furnishes, and the relations developed by the application of each individual method, we obtain something like a trustworthy indication as to the quality of the water by chemical examination, and nothing more.

16,238. And, having regard to the purpose for which it was employed, are you of opinion that Wanklyn's method is an appropriate one?—I am of opinion that for the general purposes of water examination Wanklyn's process furnishes a very useful result, that, in combination with the other method which we have used in connexion with it, it furnishes results upon which very great reliance can be placed, as indicating the purity of the samples taken from one and the same source.

16,239. (*Sir John Coode.*) And the two are the two best known to you and to science?—I think they are.

16,240. (*Mr. Norman Bazalgette.*) I will ask you another question upon Dr. Dupré's evidence; do you agree with Dr. Dupré as to the purification of the Thames water by the dissolved oxygen contained in it?—I do. I think the evidence with regard to the purifying action of oxygen is indisputable and complete.

16,241. (*Chairman.*) Do you mean the evidence that has been given before the Commission?—Yes, I mean the evidence which has been given before the Commission in connexion with the experimental examination of the water.

16,242. But you would have known that that would take place, would you not?—Yes, undoubtedly; there have been no new general results brought before the Commission. The fact that water continuously dissolves or absorbs oxygen from the air is an old and well established fact; the fact that water yields that oxygen to matters readily oxidisable dissolved in it is a well-known fact. The fact that that takes place proportionately to the rapidity with which the soluble matter is oxidised is also well known and well established. If we find, therefore, that water into which oxidisable matter is introduced shows a gradual diminution in the proportion of oxygen it contains we are sure that the rapid oxidation of the dissolved matter is proceeding. If we find that the amount of oxygen is reduced to a very small proportion, we are justified in concluding that the oxidation is proceeding almost as rapidly as the water can become re-aërated. If we find the proportion of oxygen in the water increases, we are justified in concluding that the oxidising power is gaining the mastery over the materials to be oxidised.

16,243. And you say the experiments here confirm your *a priori* opinion?—Yes.

16,244. (*Mr. Norman Bazalgette.*) I believe that there are materials of two classes which exist in suspension in a polluted river, which contribute to its power of self-purification?—Yes. I think it will be admitted on all sides that the matter which exists suspended in water deserves careful consideration in regard to its action upon a water contaminated by dissolved organic impurities. In the first place, there are certain mineral matters contained in suspension in river water which act upon certain classes of dissolved organic matter as precipitants, throwing them down in the form of insoluble materials, and, indeed, fixing them, so that they undergo very gradual change afterwards, and may be considered to be rendered practically permanent by this precipitation. Then there are also mineral matters which will have the effect of fixing any sulphur compounds which may be developed by the putrefactive decomposition of animal or vegetable matter containing sulphur, such as, for example, clays containing oxide or carbonate of iron. If by the putrefactive decomposition of the nitrogenous organic matter suspended in water sulphuretted hydrogen be evolved, those iron compounds will fix the sulphur from the sulphuretted hydrogen, and will act equally upon some other sulphur compounds, producing sulphide of iron, which sulphide of iron gives that black appearance to the mud, conveying to the uneducated mind a notion of filth and impurity which is erroneous, inasmuch as it is an indication of the purifying action of suspended matter which goes to form the mud itself.

16,245. Would the chemical action you speak of account for the black appearance of the mud depcsits of Erith which have been spoken of?—It would. I may state that one indication upon which the Commission can readily satisfy themselves by observation of this being the case is that, if that black mud be exposed to the air, it becomes brown in appearance. You can remove the brown surface, and you get a black colour underneath; but that gradually becomes brown again, consequent upon the decomposition of the iron sulphide in the mud by the action of the air.

16,246. (*Chairman.*) I have often noticed very black sewage coming from a place where one would not have supposed there was anything to make it black; for instance, from a kitchen sink; is that caused in the way you mention?—It is not at all impossible that it may be; in all probability, it may have been caused by a sulphide, either of lead or of iron; in both cases it would be black.

16,247. (*Sir John Coode.*) Sulphide of lead would be black as well as sulphide of iron, would it?—Yes.

16,248. (*Chairman.*) Does this black sulphide smell?—No, it has no smell.

16,249. But it has a black appearance?—It has a black appearance.

16,250. But does it get brown when it is exposed?—It is readily oxidised; the sulphur is readily separated, partially oxidised, and the iron is converted into brown oxide of iron.

16,251. (*Mr. Norman Bazalgette.*) I believe that on several occasions you have inspected the mud deposits of Erith, have you not?—I have.

16,252. What do you say as to the offensive smell we have heard of?—Upon the occasions of my visiting the causeway at Erith, which was in June and July last year, although I carefully searched for smell in the mud itself, I was not enabled to detect any. I found that there were many bubbles of gas collecting

*Sir F. Abel, C.B., F.R.S.*

20 June 1883.

upon the mud or collecting in the shallow puddles immediately over the mud, and by thrusting a pole into the mud gas was given off in considerable abundance. I smelt this gas, expecting to find sulphuretted hydrogen, but there was no trace of smell of any kind in this gas. I examined some of the gas bubbles upon the spot for sulphuretted hydrogen by the ordinary test, and failed to detect any. I collected some gas and took it with me to Woolwich and examined it, and I found it to consist chiefly of marsh gas; it was inflammable; it contained some carbonic acid and a small quantity of nitrogen, but not a trace of sulphuretted hydrogen. So that at any rate, upon the occasions of my inspections last summer, I was never enabled to detect the presence of sulphuretted hydrogen from the decomposition of this mud or from these mud deposits.

16,253. From your examination of the suspended matter, have you found any specimens of living animal and vegetable organisms in it?—I have stated that the suspended matter consists on the one side of mineral matter, and upon the other side it consists of animal and vegetable matters, and there is no difficulty in detecting living organisms in abundance microscopically in the fresh suspended matter in river water. The evidence which will be given to the Commission upon that by Dr. Sorbey, I have no doubt, will be quite conclusive. The action of these organisms would no doubt be a purifying one upon a water contaminated by dissolved organic matter.

16,254. (*Sir John Coode.*) Would the purifying influence be both from the animal and vegetable matter?—Yes.

16,255. (*Chairman.*) You are now referring to living organisms?—Yes, I am referring to living organisms which are nourished by the dissolved organic matter.

16,256. Capable of assimilating things to themselves?—Yes, capable of assimilating things to themselves and converting them into the ordinary products of burning or respiration. I may state that incidentally I obtained evidence of a certain amount of purifying action which, although I have not followed it far, I think may be worth mentioning to the Commission. In order to obtain conclusive evidence as to whether the Wanklyn process would be trustworthy when applied to samples of water which have been properly preserved in perfectly full bottles for several days after collection, I made a series of experiments. I collected samples of water off Woolwich Arsenal, and in each case one of the samples of water, the bottles being completely full, was set aside for a period of 14 days, while a portion of the other sample was examined by the albuminoid ammonia process immediately, or within 24 hours after collection; and it was found that the samples in the full bottles put away remained unchanged so far as the proportions of free ammonia and albuminoid ammonia were concerned which they contained. But of the sample of water which had been examined immediately, a portion was immediately filtered, through a special asbestos filter which had been heated to redness to deprive it of any possible impurity, and that was set aside in a bottle three parts full. Another portion of the original sample was also set aside in an unfiltered condition in a bottle three parts full. It was found that, allowing for a little loss of free ammonia which took place unavoidably during the filtering operation, there was but little diminution of free ammonia and no important alteration in the albuminoid ammonia in the filtered sample. But it was found, in the case of the unfiltered water which had been kept in a bottle partly full, that the free ammonia after 14 days in the perfectly closed bottle had disappeared, in one instance almost entirely, and in that two instances it had disappeared entirely. I conclude that this result was due to the action of the suspended matter contained in the unfiltered water. When that suspended matter had been removed by filtration, no such disappearance of ammonia took place.

16,257. (*Chairman.*) And applying that to the present case, inasmuch as there is suspended matter, how would it stand?—Inasmuch as there is suspended matter, in the presence of air, I consider that this suspended matter, quite apart from the effect of mineral matter which has been described, has a purifying action upon the organic impurities, or the products of decomposition of the organic matter contained in the water.

16,258. This is an additional purifying means then to the oxidation?—Yes.

16,259. (*Mr. Norman Bazalgette.*) The purifying action in these bottles being the twofold one that you have just described?—Yes; precipitation and the action of living organisms.

16,260. I believe you have inspected the river a good many times?—I have.

16,261. In what year did you inspect it?—I have inspected the river in 1878 two or three times, and again in 1880, 1881, and 1882, but more especially in 1882, and during the summer of that year.

16,262. First of all, will you tell us whether on many occasions you have been able to recognise the odour of sewage?—Except when I was actually in the sewage flow, I have only on one occasion, at a distance from the sewage, been able to recognise the distinct unmistakeable odour of sewage, and in that particular case there was a pretty steady and strong wind blowing towards me from the outfalls.

16,263. (*Sir John Coode.*) Where were you?—I was half way towards Erith from the outfalls.

16,264. That would be somewhere near Jenningtree Point?—Yes.

16,265. (*Dr. Stevenson.*) And how far would you have been from the nearest point of the outfalls?—Roughly, I should say, I would have been 1,000 or 1,200 yards from the outfalls.

16,266. (*Chairman.*) When you were "in the flow," what distance from the outfalls would you be then?—400 or 500 yards; and even there the odour was exceptional, when I was upon the river. The smell, undoubtedly, was there unmistakeably, but at a short distance, within from 50 to 100 yards. After that it becomes comparatively feeble, and you only get an occasional whiff of it, more especially when the water is stirred up by passing steamers, or by the screw on one's own steamer.

16,267. (*Sir John Coode.*) Does that answer refer to the northern or to the southern outfall?—It refers to both.

16,268. (*Mr. Norman Bazalgette.*) Upon that one occasion you have told us of, was a strong wind blowing in your direction from the outfalls?—There was.

16,269. (*Mr. Abernethy.*) Was that at high water or at low water?—It was just shortly after high water when the sewage was let out.

16,270. (*Mr. Norman Bazalgette.*) I believe it was your habit at one time, before the opening of the outfall, to travel by steamer from Westminster to Woolwich?—It was. I have been more or less intimately acquainted with the river for 35 years, and in the early days of my connexion with Woolwich I used to travel from Westminster to Woolwich by steamer. In those days, which were long before the sewage outfall days, the river was frequently in a very offensive condition, and the odour which I have of late years searched for in the neighbourhood of the outfalls, and very seldom met with, was a matter of by no means infrequent occurrence coming down the river as far as Woolwich.

16,271. For the last 28 years you have lived at Woolwich Arsenal, have you not?—I have.

16,272. Within what distance of the river?—Within 250 yards, and my place of work is 180 yards from the river.

16,273. Have you experienced any annoyance from the river?—I have not. I may state that a walk upon the river wall, or a breath of fresh air upon the T-pier at the Arsenal in the evening, has been very often my only chance of getting anything like recreation and fresh air; and I have never upon

any occasion experienced the least annoyance or inconvenience from the river at that point.

16,274. (*Sir John Coode.*) Do I rightly understand that your residence at Woolwich is 250 yards from the river?—Yes; and I have lived there the last 28 years, and my laboratory is within 180 yards of the river.

16,275. (*Mr. Norman Bazalgette.*) You have given us your own experience. Now, of course, there are many others continually employed at the Arsenal amongst whom you constantly move?—I am surrounded by a small number of houses occupied by official residents with whom I am more or less intimate; and I may state that we have had during these 28 years the usual visitations of sickness of one kind or another, but certainly in no one instance has there been any case of sickness which could be ascribed even remotely to the outfalls. I say this not simply from my own personal opinion, or as my own personal view, but that is the view of medical men living in the same place and attending upon the families.

16,276. Do the residents in the Arsenal suffer from no smells?—Yes; we are great sufferers from smells, not only in the Arsenal, but high up on Woolwich Common, the smells extending as far as Blackheath, all of which come from the large and increasing number of factories surrounding the outfalls and situated about the outfalls, and to a considerable extent up the river, as far as the Victoria Docks. I believe that there are as many as 14 manure works of one kind or other, large and small, and some of them of the most offensive description; and there are ten or a dozen chemical works, some of them very extensive. And this enumeration, I ought to say, does not include the very extensive gasworks at Beckton which favour us with smells occasionally.

16,277. I believe you dealt with these nuisances in a report in 1866, did you not?—I was called upon by the Secretary of State for War, in conjunction with an Army medical officer and the Royal Engineer officer in charge of the Arsenal, to examine into the complaints that were made at that time of emanations from those works which were growing up all round about the outfalls, which at that time had not been long established; and we, in fact, found that there was a substantial cause for the very great complaints which were made against those works in consequence of the development of noxious vapours by the careless manner in which the various operations connected with the conversion of refuse animal matter into manure, and other kindred operations, were carried out.

16,278. I believe you were a member of the Royal Commission on Noxious Vapours which sat in 1877?—I was.

16,279. Was there evidence laid before that Commission on account of the nuisance arising from the works in this neighbourhood?—There was a very large amount of evidence collected by the South-Eastern Sanitary Association and brought before the Commission with respect to the character of the odour arising from works at Deptford and down as far as Northfleet. Amongst the witnesses examined was Professor Heaton, who has given evidence here, and several well-known medical authorities; and I think the whole of the evidence was quite conclusive as to the very considerable extent to which the neighbourhood suffered from the emanation of noxious vapours from those factories. There was not one allusion, even a remote one, to the sewage outfall contributing in any degree, or the discharge of sewage into the river contributing in any degree, to nuisances that were suffered in the neighbourhood.

16,280. (*Sir John Coode.*) Did the South-Eastern Sanitary Association make any allegations against the sewage?—There was not a word said about it.

16,281. (*Mr. Norman Bazalgette.*) Originally I understand this case arose from the action taken by the South-Eastern Sanitary Association?—Yes.

16,282. But they did not complain of the sewage?—Not in the least.

16,283. Was no suggestion made that any of the nuisance proceeded from the outfalls at the time?—No. I have again carefully looked through the evidence, and there is not a syllable about it.

16,284. Having regard to the analysis, have you found that there has been of late years an increased pollution of the river?—I have carefully examined the analytical results which have been collected in the experiments made on both sides recently, and I fail to see any evidence of an increasing pollution of the river. On the contrary, I feel confident that it has been well established that the river is competent to deal with the amount of impurity discharged into it, and that the purifying power is at the present time in excess of the polluting influences.

Cross-examined by Mr. Lumley Smith.

16,285. One word with regard to this Commission on Noxious Vapours: that was a limited inquiry, was it not; that was to inquire into complaints which had been made of certain factories?—It was an inquiry into the grievances of particular districts in consequence of the emanation of noxious vapours.

16,286. From factories and chimneys and other things?—Or from any other source.

16,287. But "noxious vapour" was not interpreted to mean an accusation against the river?—But it spread very largely into an inquiry into the pollution of the streams.

16,288. Into the pollution of the streams from factories?—From factories.

16,289. But you do not suggest that upon that occasion the Commission went into the matter of the River Thames at all?—Certainly not.

16,290. It was not within the scope of their inquiry, I presume?—No.

16,291. Now, with regard to the progressive increase, you are speaking of the deduction you draw from the tables of analysis which have been put in here?—Yes.

16,292. When you speak about the progressive increase, as the population increases, necessarily the amount of sewage will increase, that must be so, must it not?—Certainly.

16,293. What is your view; you laid some stress upon the words that "at present" the purifying power was sufficient, I do not quite know what you meant by that?—I meant that as far as the examination had gone the purifying power was at present sufficient, and that, in fact, the purifying power was in excess of the polluting influences.

16,294. The time may come when the river will not be equal to the task that may be put upon it, but you consider at present it is equal?—I consider that, as far as one is enabled to draw a fair conclusion from facts, a very much greater degree of pollution may be satisfactorily dealt with, as far as the river is concerned, in the way in which it is dealt with now.

16,295. Do you consider the river never becomes offensive from the presence of sewage?—I would not say that.

16,296. You are not prepared to say that on certain occasions and at certain temperatures the river does not become offensive in consequence of the presence of sewage?—Within a particular and very limited area, it may be.

16,297. That probably has been within your own knowledge, have you never found the river offensive?—No, I have not; else I should have stated so. I have never had occasion even in the hottest summer in recent days to notice the smell from the river.

16,298. (*Chairman.*) Taking it from side to side of the river?—Only when I have been taking special observations right in the sewage stream.

16,299. (*Mr. Lumley Smith.*) There has been a good deal of evidence given that at certain times in

*Sir F. Abel, C.B., F.R.S.*

20 June 1883.

hot weather the river becomes very offensive from the sewage, are you prepared to doubt that that is so, or can you give any explanation why it should be the case?—I can only give you my own experience, and I can only tell you, though it is not strictly evidence, that my evidence would be confirmed by many who have lived in the arsenal.

16,300. You are judging by your own experience?—Yes, I am.

16,301. Now, with regard to Woolwich itself, is it not the fact that complaints have been made by residents as to the sewage?—Not of my own knowledge; I believe that upon several occasions complaints have been made of smells which not unnaturally have been ascribed to sewage, because they have been due to offensive odours somewhat like, though much more intolerable than, the odours evolved from sewage. I refer especially to the odours coming from the fish manure works, which are so disgusting that I trust the Commission may have the chance of experiencing them for a moment. I am not at all surprised that they have been ascribed to emanations from excreta; for I am convinced that in many instances, and certainly at Woolwich, smells of this description have been mistaken for smells emanating from the sewage outfalls.

16,302. However you agree with many of the witnesses that you can distinguish between the sewage outfalls and the factory smells?—The educated nose can; the popular nose, when it is in the neighbourhood of the sewage, would say, that is a sewage smell, when it smells any smell.

16,303. Yours, I presume, would be an educated nose?—To a certain extent it would be.

16,304. It does not want a person who is a scientific chemist to detect the difference between the smell of sewage and the smell of factories?—It wants a person who will give himself the trouble to observe and discriminate.

16,305. You do get rather accustomed to smells in the laboratory, I suppose?—I used to; but I am sorry to say that my official work takes me so much out of the laboratory that my nose has become sensitive again.

16,306. And you do not require to go now to your pier for your fresh air, you get your oxygen in other places?—Yes.

16,307. But the time when you used to go for your smell or whiff of fresh air, was that at a time when you were much engaged in the laboratory, and your nose was not sensitive?—I have still a lingering fondness for a seat upon the T-pier of the Arsenal.

16,308. Now, with regard to this smell at Jenningtree point, you smelt it when you were in the heart of the sewage?—Yes.

16,309. I presume that was on an occasion when you went down for the purpose of this inquiry?—Yes.

16,310. How many times have you been down for the purpose of testing the smell?—I have been down there seven times.

16,311. Was that going down in a small screw steamer, and then steaming away again?—No; going to Erith, and considerably beyond; to Northfleet, sometimes.

16,312. But on this occasion when you smelt the smell, what time of the year was it?—I believe that that occasion was on the 5th of August.

16,313. Did you make any memoranda as to the distances out at which you lost the smell upon those different dates?—I did not, because it was only a passing smell, a whiff as you would call it.

16,314. But if you took the steamer through the sewage, you must have got the sewage on each journey once?—I did.

16,315. But you have not made any memoranda as to the distance at which you lost it?—I have not.

16,316. Now, taking the water which was put unfiltered into a bottle, that water was put into a bottle three-fourths full?—It was.

16,317. Was it corked?—It was stoppered.

16,318. It was not filtered, and therefore there was certain suspended matter in it, not matter in solution, but suspended matter?—There was both matter in solution and suspended matter.

16,319. The matter in solution would be very much the same in either sample, would it not?—Yes.

16,320. But the matter in suspension would differ?—Yes, it would.

16,321. What is the process that takes place?—I will not attempt to speculate upon the precise action, but I imagine it might be due to animal or vegetable organisms existing in the suspended matter.

16,322. Do you mean alive or dead?—Alive.

16,323. Animals?—I would not presume to say whether they were animals or vegetables.

16,324. Which would produce sewage of their own, I presume?—That must be very minute, but still I presume they would have excreta.

16,325. Did you test the oxygen to see whether the free oxygen remained the same in that bottle?—I did not. I should say that in all probability it did not.

16,326. May it not be the fact that the ammonia may have been oxidised by the oxygen, and not by the suspended matter?—In that case it would have been equally oxidised in the filtered sample. In one case I removed the suspended matter, and in the other case the suspended matter remained. If the disappearance of the ammonia were due simply to the oxygen contained in the bottle, it would have been a matter of indifference whether the suspended matter were there or not.

16,327. But may it not be that the suspended matter acts as a sort of carrier of the oxygen, so as to bring it to work upon the ammonia?—I will not say it is not so, but still it acts upon the suspended matter, and I incline to believe that it is due to the action of the organisms acting on the suspended matter.

16,328. If it merely assisted the oxygen to act on the ammonia, the work would have to be done by the oxygen and not by the suspended matter?—The work would have to be done between the two.

16,329. What are those living organisms which you think devour the sewage; diatoms and bacteria?—That may be so, but I would not pretend to go into that matter.

16,330. This was a sample off Woolwich Arsenal, was it?—It was.

16,331. What time of the year was it taken; was it taken at a time when the suspended matter was large or small?—The samples were taken in August, September, and October.

16,332. Was that last year?—Yes.

16,333. Ammonia disappears very freely, does it not; in the mere pouring off of the water some of the ammonia disappears?—Yes, but this is quite a different thing. In the case of the unfiltered water, which was in a perfectly closed bottle, the ammonia did not disappear at all or only to a very slight extent; so there was no error of experiment to account for the disappearance of ammonia. A certain amount of ammonia disappeared from the filtered samples, which was due to the fact that the water was exposed for a certain amount of time during filtration, but the extent of disappearance was small compared to the total disappearance, when the suspended matter was present.

16,334. Is it your view again that the blackness of the mud is entirely due to the sulphide of iron?—I will not go so far as to say that it is entirely due to that, because I believe it would be difficult to prove that it is entirely due to that: but I believe it is chiefly due to that.

16,335. Where does the iron come from?—From the suspended matter contained in the water, from the saltings which are washed into the water.

16,336. The sewage itself is black, is it not?—I was not aware of that.

16,337. His Lordship put the case of sewage coming out of a sink being black, and for myself, I thought it was generally black?—I think, when you

come to examine it properly, you will not find it black; it is dark-coloured undoubtedly, but it is certainly not black.

16,338. I was going to ask you where the blackness of sewage came from, but you do not agree that it is black?—I cannot agree that it is black.

16,339. Where does the iron come from that discolours it, as you say?—From the mineral suspended matters which are continually washed about in the river and deposited on the saltings.

16,340. Then the saltings themselves ought to be black. If the iron from them turns the other mud black, why does not it turn the mud upon the saltings black?—So it would if they were exposed long enough.

16,341. But they are exposed for a great part of the tide and during the year, so why are they not black?—Because they have not the opportunity of being subjected to this process of being mixed up in a finely divided state with the sewage in the water and thereby undergoing change as the sewage mud does.

16,342. Now as to the iron, I suppose that comes from the road detritus. Every wheel that goes round, I suppose, leaves a certain amount of iron upon the roads?—And from the horse shoes; there is no difficulty in finding iron in the detritus.

16,343. May it not be that this blackness that you see upon the mud at the banks at Erith and elsewhere is coming from the blackness of the sewage?—Certainly not.

16,344. (*Chairman.*) Do you say that none of it has so come?—I do not say none of it, but that that amount of jet-black appearance cannot have been produced in that way.

16,345. (*Mr. Lumley Smith.*) A great deal of the iron you found in the mud would have come largely from the iron of the wheels which is worn away upon the roads?—Yes, no doubt it would come down through the sewers.

16,346. That goes through the sewers and is deposited upon the banks in the neighbourhood of Erith and elsewhere?—Yes.

16,347. Why does not it blacken the saltings from which it is taken?—It does to a certain extent.

(*Chairman.*) Supposing this were iron brought down by the sewers, what harm does it do?

(*Mr. Lumley Smith.*) It shows that it is sewage mud which is there; the iron itself would do no harm.

16,348. (*Chairman.*) Is there more of this black covering near the outfalls than there is lower down or higher up?—The largest amount I have seen of it is in the neighbourhood of Erith; it has varied a good deal. Some years ago, between Erith and the outfalls, there used to be a much greater deposit of that particular kind of mud than there is now.

16,349. Do you find it all along the river?—I would not speak to the river generally, but I know it has existed there, because I have used the mud deposits for experimental purposes.

16,350. (*Sir John Coode.*) You would say that the blackness is not a measure of the offensiveness of the mud?—Not in the least degree.

16,351. (*Dr. Stevenson.*) What is the colour of the mud, do you know, in the other parts of the Thames?—A brown colour generally; it is sometimes of a black tinge, but it is generally brown.

16,352. (*Prof. Williamson.*) I understand you to express the opinion that the black colour is the result of two things, partly the sulphur and other organic substances in the sewage, and partly the iron which comes from the roads through the sewage, and partly from the suspended clay which comes down the river?—That is so.

16,353. It is not the sewage itself, but a product of the sewage?—The result of sewage entering the river.

Cross-examined by Mr. Beaumont Morice.

16,354. You mentioned something about the gas bubbles, have you noticed that feature on many occasions?—I have noticed it on every occasion, whenever I have been to the mud in the neighbourhood of Erith; it varies considerably in quantity.

16,355. Did you notice any sewage smell at the places where you noticed these bubbles?—No, I did not notice any sewage smell.

16,356. Have you taken any or many analyses at the parts where those bubbles occurred?—I merely collected the gas from those bubbles.

16,357. Did you do that upon more than one occasion?—Yes, upon more than one occasion.

Examined by the Commission.

16,358. (*Chairman.*) I suppose you have heard about fish being suffocated or poisoned or put an end to as low down as Gravesend?—Yes.

16,359. I suppose you attribute that to the effect of the sewage?—I do.

16,360. The sewage is sensible there, if I may say so, it is not so destroyed or mixed up that you could say it is no longer sewage, I suppose?—There is no doubt there must be sewage there, but I cannot say that I consider the disappearance of the fish from that part can legitimately, by a process of exhaustive reasoning, be ascribed to the action of the sewage direct; when I speak of its disappearance being due to sewage, I mean in this way that the oxygen of the river is so constantly actively employed in oxidising the sewage matter that is sent into the river that there is not sufficient oxygen there to support the life of fish.

16,361. Now tell me this, although I think I can guess the answer, but we have heard that some matters putrify, and others get oxidised. I understand the same thing might either putrify or be oxidised?—There is no exact line to be drawn between the occurrence of the two charges; putrefaction is accompanied by oxidation; you can draw no line at which you can say that a material simply putrifies and does not oxidise, the oxidation proceeds concurrently with the putrefaction.

16,362. Is this anything like a reasonable guess on my part, that oxidation would take place instead of putrefaction if the oxygen could get to each of the particles with great facility, whereas, if it cannot, putrefaction would take place?—It can hardly be that, because it depends very much upon the conditions as regards temperature and exposure to the air which surround the question, but there are certain animal substances which are much more liable to putrify than others, and some which would more readily oxidise if they were exposed to conditions favourable to oxidation.

16,363. Why should not there be putrefaction in mud, as I understand Dr. Tidy says is the case. Could you tell *à priori* that it would not putrefy, and if so, why?—I could not say. In fact, I should say that, given putrescible animal matter in mud, and expose that to the necessary temperature such as a summer heat, it must of necessity putrify, but oxidation will be going on at the same time.

16,364. Is your answer to this effect that the matters brought down by the sewage, which may be more or less deposited upon the mud, are more likely to be oxidised than to putrify?—That would entirely depend upon the conditions to which they were exposed. If the animal matter were upon the surface, as in the case of mud upon the river's bank, and were exposed to the heat of the sun, the tendency would be

*Sir F. Abel, C.B., F.R.S.*

20 June 1883.

to putrefaction in the first instance. If the matter were mixed up and associated with the oxygen dissolved in water, there is no doubt putrefaction might commence, but the oxidation would commence so rapidly that you cannot draw a line between them.

(*Dr. Tidy.*) There is no doubt about that being the case.

16,365. (*Dr. de Chaumont to the witness.*) From your experiments upon the ammonia in the water, did you ascertain by analysis what became of the nitrogen?—I was unable to carry the experiments so far, but I have no doubt we have an increase of nitrogen oxides; there might also be an assimilation of nitrogen by the animal and vegetable organisms. My object was to ascertain whether one might rely upon getting trustworthy results in the examination of samples of water when we were compelled to preserve them for some considerable time after their collection, and I found that one could, and incidentally I made these observations with respect to the effect of the suspended matter upon ammonia.

The witness withdrew.

Dr. Augustus Voelcker, F.R.S., called in; examined by Mr. Norman Bazalgette.

*Dr. A. Voelcker, F.R.S.*

16,366. You are a Fellow of the Royal Society, Consulting Chemist to the Royal Agricultural Society of England, and were formerly Professor of Chemistry in the Royal Agricultural College, Cirencester?—Yes.

16,367. I will not take you through your experience, as probably the Commission will take that for granted, First of all, to clear up one point, I will ask you this question: were you with Mr. Dibdin when he saw the slaughterhouse refuse, as to which he spoke, lying upon Erith foreshore?—Yes, that was last Saturday.

16,368. Will you tell me what your impression was of that?—All I can say is that there was an abominable nuisance arising from the refuse of the slaughter-houses. The smell was most disgusting. We counted no less than 14 sewers, or sewage pipes, that discharged their contents upon the foreshore. There were also entrails, bits of skin, and similar animal matters all scattered about the shore.

16,369. Was what you saw at Erith sufficient, in your judgment, to account for the complaints of nuisance from the people who work in the mud and along the foreshore there?—Yes, quite so. The fact is, it was such an abomination that Sir Frederick Bramwell, who walked with us, would not venture to go very far. He backed out of it as soon as he could.

16,370. In the months of June, July, and August 1882, I believe you made several inspections of the river with Dr. Dupré and Mr. Dibdin?—Yes, from Westminster to Purfleet.

16,371. And you returned, I believe, over the same range of river?—Yes.

16,372. What did you do upon most of those visits?—We took note of the neighbourhood and the condition of the river, more especially to ascertain if there were any bad smells arising either from sewage discharge or other sources.

16,373. Speaking generally, first of all, what did you find. Did you find that there were bad smells arising from the river?—No; except direct in the sewage stream, the river water does not give off any disagreeable smell. Of course, when you are in the stream of the sewage, the smell, as you might naturally imagine, is bad, but it gradually disappears, and at a distance of about 600 or 700 yards, according to the state of the wind, and whether the air is calm or windy, the sewage smell entirely disappears, and even when the water is shaken up and sniffed at, you get only the faint smell which is perceptible all along the river (perhaps gradually increasing as you go under London Bridge, where it is sometimes a little more perceptible), but all along from Westminster through the bridges to Erith you have this peculiar mawkish smell, reminding you of half-dried linen, or something of that sort.

16,374. So much for the river. Did you find that the factories were equally innocuous as regards smells?—The factories discharge a very large quantity of a most penetrating, disagreeable smelling, vapour. There are a great many factories all along the river, and I know what is produced in them. Taking the nearest point at Cubitt Town, you will have there the extensive artificial manure works of the London Manure Company, where something like from 40,000 to 50,000 tons of artificial manure, such as blood manure, dissolved bones, artificial guanos, and a variety of compound manures, are manufactured. The smell which is produced upon the addition of sulphuric acid to some of the refuse material, such as blood, or fish, is most obnoxious and penetrating. It is not due, I need hardly say, to any ammoniacal emanations, but to the volatile fatty acids, propionic, phocenic, and similar volatile fatty acids. The odours will travel a long distance, and are perceptible, to those who are accustomed to that kind of smells, to perhaps three quarters of a mile up and down the river, when the wind blows in the proper direction.

16,375. May we take it that upon these several occasions when you went down the river you did not smell the river, but you did smell the factories?—Distinctly.

16,376. What considerations do you think would guide you to a judgment of the comparative degree of the purity of a tidal river into which impurity is discharged?—I would be guided by the character of the suspended matter, that is to say, whether the suspended matter was more of a mineral nature, or of a combustible nature. The more organic or combustible matter is mixed up with the suspended matter, the more offensive it is, speaking generally. Then the next question is the degree of aëration, the more oxygen there is present in the water, the more it approaches the point of complete saturation with oxygen, the better, other circumstances being equal, the water would be. Then, in the third place, I would look upon the amount of oxygen which is readily consumed as indicating the comparative degree of putrescibility, that is to say, if matters are present in water which are readily oxidised and consume a good deal of oxygen, that water will be a bad one. If, on the other hand, not much oxygen is consumed, we may fairly conclude that putrescible matter is present in but small or, it may be, insignificant proportions.

16,377. Have you applied these considerations to the Thames below the outfalls?—Yes, by following out the method we have adopted in our inquiry, that is to say, by taking account of the suspended matter—of the character of the suspended matter—the amount of oxygen consumed, and the amount of albuminoid ammonia found.

16,378. Will you state shortly the conclusion at which you have arrived with regard to each of those considerations, and then the general conclusion at which you have arrived?—The general conclusion is that which has been already stated by Dr. Dupré.

(*Chairman.*) With a witness of such eminence as Dr. Voelcker, one is extremely unwilling to cut him short; but if he has nothing to say except that he agrees in what has been already said, you might put that to him and ask him, is there anything you would like to say in addition?

(*Witness.*) I should like to say that I have found in the most polluted Thames water nitrates present. We have not included those in our report, in order not to make it more complicated than it is already at present, and not to introduce details which might have

a confusing effect; but I may say that I have invariably found in Thames water nitrates present; they evidently arise from the oxidation of nitrogenous matter, showing the readiness with which animal matters are converted into nitric acid even in the presence of suspended matters which one would imagine to have a reducing effect: but, notwithstanding the presence of suspended organic matter, I have invariably found nitrates in Thames water polluted with sewage. In the sewage in the reservoir itself I find no nitrates. Here you have free and albuminoid ammonia, and no nitrates, evidently because there is not sufficient oxygen present to produce the nitrates; but even within a short distance, say 1,000 yards of the outfalls, or in any part of the river, you will find invariably nitrates present. This clearly shows that there is an over-abundance of available oxygen present to destroy, I should say, not the whole of the organic matter, because I do not know what the whole of the organic matter is, but the most obnoxious part, the most putrescible kind of organic matter; and so far it is very comforting to know that at no time of the year, and under no circumstances, was there a lack of available oxygen to burn up, so to speak, the most objectionable organic matter, and so as not to create anything but a mere local nuisance. That there is a local nuisance one cannot deny; you cannot discharge a large body of sewage from an outfall without creating a local nuisance, but it is remarkable how quickly this peculiar sewage smell is destroyed, and I am perfectly certain in my own mind that people who have not educated noses, or experience with regard to these smells which are given off from the factories on the banks of the Thames, and I may say I am intimately acquainted with most of them, and can discriminate by the smell one factory from the other,—I say I am sure that most people who are not acquainted with these facts mistake certain animal emanations, such as come from the fish manure works, especially in a dilute condition, for sewage. It is that peculiar animal nasty smell which often is more like that of sewage in a highly diluted state at a long distance from the factory than in the immediate neighbourhood.

16,379. (*Mr. Norman Bazalgette.*) When you speak of a local nuisance, within what limit would you localise the nuisance?—I should say, not more than 1,000 yards, if so much.

*Dr. A. Voelcker, F.R.S.*

20 June 1883.

16,380. Upon each side or on one side?—From the outfalls downwards.

16,381. Do you agree with Dr. Dupré and Sir Frederick Abel that the dissolved oxygen to be found in the Thames water is more than sufficient to oxidise the polluted matter which is poured into it?—Certainly.

16,382. Do you agree with those gentlemen whose names I have mentioned that Wanklyn's method is the right method to employ for the purpose for which it has been employed?—Yes, for giving comparative results.

(*Mr. Norman Bazalgette.*) Now, my Lord, Dr. Voelcker has made a special inspection of all the nuisance factories between the outfalls and Erith, and I would like to put questions with respect to them shortly to him.

(*Chairman.*) I think that would be important.

(*Witness.*) Eliminating those which do not create a nuisance, and only mentioning those which do produce a nuisance, the first, which I have already alluded to, is the London Manure Company's works, at which they produce from 40,000 to 50,000 tons a year. Then we come to the considerable works of W. R. Goold and Company, artificial manure manufacturers, which are in close proximity to Messrs. Pursers of the London Manure Company's works. Approaching the Victoria Dock, the smell upon the river becomes very offensive, and remains so for a considerable distance from the following works: Messrs. James Gibbs and Company, artificial manure works, dissolved guano, blood manure, and the like; they must make something like 60,000 tons a year, I should say. Then Odam's Nitro-phosphate Blood Manure Company almost joins the works of Messrs. Gibbs. They probably make per annum more than 60,000 tons of artificial manure. Next door to Messrs. Odam's works we come to Messrs. Thomas Farmer and Company's artificial manure works, where a good many thousand tons of artificial manures are manufactured in a year; and then there are still more extensive works, standing on about 2½ acres of ground, belonging to Messrs. Ohlendorff and Company.

Adjourned to Tuesday next at half-past 12 o'clock.

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# FORTY-THIRD DAY.

## Tuesday, 26th June 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.

FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
WILLIAM POLE, Esq., F.R.S., *Secretary.*

DR. AUGUSTUS VŒLCKER F.R.S. called again; further examined by MR. NORMAN BAZALGETTE.

16,383. When we broke off on the last occasion, you were giving the results of a special inspection which you had made of the various manufactories upon the banks of the Thames, which in your judgment would continue the nuisance—would you go on where you broke off?—I think the last works I alluded to were Messrs. Ohlendorff's dissolved guano works, which are very extensive works for the manufacture of dissolved guano; they have also large stores of Peruvian guano, and manufacture dissolved bones and similar refuse manures.

26 June 1883.

16,384. (*Chairman.*) Where are they?—At the Victoria Docks Tidal Basin. There is a group of artificial manure works beginning with Messrs. Gibbs's, followed by Messrs. Odam's Nitro-phosphate or Blood Manure Company's Works. Next come the works of Messrs. Thomas Farmer and Company, and the last of that group, which as I have stated are all close together, are Messrs. Ohlendorff and Company's Peruvian guano works. Then a little further down at Silvertown are the soap works of Messrs. Knight and Sons.

*Dr. A. Voelcker, F.R.S.*

26 June 1883.

16,385. Their works might be smelt in Woolwich Reach, but I do not suppose any of those works would be smelt as low down as Barking Creek, would they?—That depends a good deal upon the direction of the wind and whether the manufacture is carried on well, or in a careless manner. At the present time the smell cannot perhaps be very considerable, because the manufacturing season has just ceased. After the turnips are sown, practically but little dissolved guano or other artificial manures are sold, and the nuisance at the present time would not be so great as in the spring when there is a considerable pressure of business.

16,386. Would that ever be smelt at Barking Creek?—At Barking Creek there are other works which smell.

16,387. But would those ever be smelt at Barking Creek?—I should hardly think they would be smelt so far; 3 miles is a considerable distance, but all along from there down to Barking Creek, there is a succession of smells which sometimes are stronger than the sewage, and then you get another kind of oily smell.

16,388. (*Mr. Norman Bazalgette.*) Then I think you come to Messrs. Simpson and Company's Petroleum Stores?—I do not think there is very much smell coming from these stores, but still there is the prevailing oily smell, which is perceptible wherever large numbers of petroleum casks are stored.

16,389. Will you continue your statement, simply calling attention to those works from which you think a special nuisance arises?—Then we come to the ammonia works and the tar works of Messrs. Bird, Bolton, and Hayward. Like all tar works there works spread a strong smell, and when sulphate of ammonia is made, sulphuretted hydrogen unfrequently is given off.

16,390. (*Mr. Michael.*) And that is not a very pleasant smell?—No; at times it is very strong. The last time we went down the river, last Saturday week, the smell of sulphuretted hydrogen coming from the Beckton Gasworks was very powerful.

16,391. That was from the sulphate of ammonia works there, was it not?—Yes; that was from the sulphate of ammonia works.

16,392. (*Mr. Norman Bazalgette.*) I think we will deal with the Beckton Gasworks as we go along—perhaps you had better follow your list in order?—Then we come to the chemical works of Messrs. Spencer Chapman, and the chemical manure works of Mr. Mark Finch, and those are succeeded by the Silvertown India Rubber and Gutta Percha works. I do not know that the last-mentioned give off very much smell. Then follow Messrs. Petty and Cairns' oil mills; there is that pervading oily smell which hangs about all oil mills. Then we come to the extensive Beckton gasworks, where large quantities of sulphate of ammonia are manufactured, perhaps something like 30,000 tons in the course of the year; they are the most extensive sulphate of ammonia works in the Kingdom.

16,393. Could 30,000 tons of sulphate of ammonia be manufactured without a considerable amount of sulphuretted hydrogen being evolved?—Yes, it could, if great care were taken either to absorb or to burn off the sulphuretted hydrogen.

16,394. But do they as a matter of fact?—When a manufacturer is hard pressed, and a large order has to be executed in a given time, the operations are unduly pushed on, and, as a matter of fact, sulphuretted hydrogen is allowed to escape in sulphate of ammonia works, and we had a practical proof of this the last time we went down the river when sulphuretted hydrogen in considerable quantities was being given off from the Beckton gasworks.

16,395. In addition to the sulphate of ammonia, is there also a good deal of gas lime produced?—Yes; there is a good deal of gas lime produced which is an unsaleable commodity in that locality; people do not know what to do with it. However useful gas lime may be in a district where there is no lime in the soil, it is a drug there. Even the ordinary refuse lime from the soapworks which is produced at Silvertown has to be carried out to sea.

16,396. Is gas lime a fragrant product?—It is a very disagreeable smelling product indeed. It has a very persistent smell; it smells of sulphuretted hydrogen and gas and tarry matters, but it is mainly the sulphuretted hydrogen which is given off on the exposure of the gas lime to the air which creates the nuisance; and there must be very considerable quantities of gas lime produced at the Beckton gasworks. That gas lime has to be carried away in barges which do not spread a very nice flavour as they go along the river.

16,397. Now will you pass on to the next manufactory?—The next manufactory is the works of Messrs. Lawes, which occupy several acres of ground with sulphuric acid works and artificial manure works. Messrs. Lawes' works manufacture certainly not less than 50,000 or 60,000 tons of various manures, such as blood manure, dissolved guano, super phosphate of lime, and similar manures. Then a little lower down the river, not very far from Messrs. Lawes' works are some very bad smelling stores and works, the guano stores of Mr. Daniel DePass, who imports guano from Patagonia, which is more powerful in its smell than the Peruvian guano, being wetter and a fresher product than the Peruvian guano, which we now obtain from the south of Peru.

(*Chairman.*) I suppose we might almost take it for granted that the reason these works are all there is, that they might be out of the way of those people who would complain of them, and that, therefore they are in a very reasonable position.

(*Mr. Beaumont Morice.*) This matter is not contested; we do not say but what there are plenty of these manufactories down the river.

(*Witness.*) I noticed a peculiar fish smell from works lower down the river, and nearer Erith which belong to a Mr. Laing, who works up the fish refuse from Billingsgate, and makes it into a dry fish guano; perhaps that is the greatest offender next to some fish manure works upon the opposite side of the river belonging to Mr. Johnson. Johnson's fish manure works we could distinctly smell the last time we went down the river, and also upon previous occasions; they are the fish works which produce the greatest nuisance. The smell of fish manure travels such a long distance and is very persistent in its character, it is not easily destroyed; you cannot oxidise as you can perishable substances. Decomposing flesh is more readily destroyed, but from these fish works you get volatile fatty acids which travel a long way; they are very persistent.

16,398. (*Mr. Norman Bazalgette.*) Can you tell us from your personal experience whether the smell from these fish works is perceptible at Erith?—Certainly; upon several occasions we have smelt it. When the wind is in that direction it is constantly smelt.

19,399. We have not got half way down the list, but I will not continue the detail of this part of the case any further.

(*Chairman.*) If you were to say that within a certain space there are so many manufactories, would not that be sufficient?

(*Mr. Norman Bazalgette.*) The reason I was giving this evidence was that your Lordship was pleased to say upon the last occasion that this evidence was important.

(*Chairman.*) I do not recollect saying that, but I have no doubt I said it from the fact that several witnesses had said that they had smelt smells, and that those smells could be shown to proceed from manufactories down the river.

Cross-examined by Mr. Beaumont Morice.

16,400. Do not the factories that you have mentioned lie between Woolwich and the Crossness outfall mostly?—A good many do.

16,401. And many more close to the Crossness outfall?—No doubt.

16,402. Were you able to discern the difference between those smells and the sewage smell?—Yes.

16,403. Do you say that the sewage in the reservoirs is at all altered before it gets into the river; is it at all purified upon the way down the sewers?—No.

16,404. Not at all?—I do not say that it is not at all purified, but it is a liquid which is in constant change, as soon as it is discharged it gets away.

16,405. But what I want to know is, does any purification take place of the sewage by the time it gets into the reservoirs?—I am hardly prepared to say whether it does not smell stronger or less so.

16,406. Let me draw your attention to the evidence you gave upon the Essex Reclamation Bill. You were asked, "Do you think the sewage would be just as "good 40 miles from town as it would be 5 miles "from town," to which you replied "I think so"; do you agree to that?—Yes, that meant for agricultural purposes.

16,407. That it remains for all practical purposes in the same condition, as sewage?—No, it gets purified; it may become almost inocuous, so as not to create any nuisance upon being applied to the land.

16,408. (*Sir John Coode.*) And might not that very well be so without the fertilizing properties being diminished?—Yes; in fact, as I contend, the inodorous and clarified sewage is the better for irrigating purposes; if you could filter it, it would be better.

16,409. Why so?—Because the suspended matter produces upon the surface of the soil a mechanical obstruction; it closes up the pores.

16,410. Do you mean to convey to the Commission that it is more finely divided and therefore in a better condition for distribution over the land; is that what you wish to convey to us?—The most valuable fertilizing matters occur in sewage in perfect solution, whereas the suspended matters are comparatively of little value, and when they are deposited upon the surface they form a crust which is injurious to the vigorous growth of plants, and which neutralizes, to a certain extent, the fertilizing properties of the soluble matter in the sewage. At 40 miles sewage is as good as at five for agricultural purposes, if not better.

16,411. (*Mr. Beaumont Morice.*) Did I understand you to say that you found no nitrates present in the reservoir?—That is so; not in the reservoir.

16,412. May I take it from you that there has been no purifying action upon the sewage up to that period?—I do not think it will have much purifying action except the mechanical deposition of any suspended matter.

16,413. Now I will draw your attention to another point; you would not advice sewage being dealt with or used in proximity to any towns or inhabited places, would you?—Certainly not, unless there are very perfect precautions taken to remove the suspended matter which causes all the nuisance.

16,414. You have mentioned the refuse lime from these gasworks; do you know what is done with the refuse lime from the gasworks at Beckton?—I take it, that it is carried out to sea.

16,415. But you do not know positively?—I do not know that with regard to the gasworks, but I know it with regard to Messrs. Knight's works.

16,416. (*Chairman.*) I understand you to say it must be got rid of at any rate?—Yes, it must be got rid of; there is no sale for it. I know with regard to Messrs. Knight's soap works that they carry it out to sea.

16,417. (*Mr. Beaumont Morice.*) You do not say that it goes into the river?—I do not.

16,418. You have mentioned the particular fish smell that you smelt; have you often been at Erith and smelt that smell there?—Yes, perhaps I have been at Erith half a dozen times, at various times in one year. During this inquiry I was altogether eight times at Erith, and upon two occasions which I distinctly remember, I have smelt it.

16,419. Have you smelt other smells at the same time?—At Erith?

16,420. Yes?—I was so impressed with the fish smell that I did not trouble myself about the other smells.

16,421. That was above everything else, was it?—Yes, it killed all the other smells.

16,422. Now, only one more question—you stated that the sewage may be a local nuisance?—Yes, it may be.

16,423. Have you ever followed and seen how far you could trace the sewage from the outfall?—Do you mean visibly or by the smell?

16,424. I mean by the swell?—By the smell I should say not above 600 yards, if so much.

16,425. Have you followed it down?—Yes, at about 1,000 yards it loses its colour and is lost in the general stream.

16,426. What time of the year was it that you did that?—In the months of July and August last year.

16,427. Do you remember what the weather was at the time?—The weather was rather cool, it was a very cold summer last year, at least the summer months were cold.

16,428. I think you were with Mr. Dibdin when you mentioned about the slaughterhouse at Erith, were you not?—Yes, I was with him. Mr. Dibdin, Dr. Dupré and myself and Sir Frederick Bramwell, went down a part of the way, but Sir Frederick did not venture far.

16,429. I should like you to tell the Commission exactly what you saw, was it anything more, I mean, than some blood trickling down from a butcher's shop?—Yes, certainly; it was so bad that it was dangerous to walk about for fear you would tread in some horrible mess; we counted 14 drains of smaller or larger dimensions.

16,430. What time of the tide was this?—It was low tide. Then the beach was strewn about with entralls and refuse of animals.

16,431. Did you notice any sewage smell there as well?—No, I cannot say I did.

16,432. Did you notice any sewage mud?—Yes.

16,433. You did?—Yes, I did, and I tried to smell it, but I could not, it did not smell.

Re-examined by Mr. Michael.

16,434. What is about the distance, when sewage farms are established in the neighbourhood of towns, that they are taken from inhabited dwellings, what is your limit?—I do not know that I should feel inclined to prescribe any limit.

16,435. (*Sir John Coode.*) What is the nearest you know to a town?—The sewage farm at Bedford is close to the town.

16,436. (*Mr. Michael.*) With paths running through frequented very much by the inhabitants?—Yes.

16,437. And conducted without any nuisance whatever?—Yes.

The witness withdrew.

DR. WILLIAM ODLING, F.R.S., called in and examined by MR. MICHAEL.

*Dr. W. Odling, F.R.S.*

26 June 1883.

16,438. You are a Fellow of the Royal Society, a Fellow of the Royal College of Physicians, and Professor of Chemistry in the University of Oxford?—I am.

16,439. I think you have been acquainted with the river Thames for the last 25 years?—I have.

16,440. And you have been very largely engaged in investigations as to its character?—Yes; I was engaged largely in such investigations in the years 1857 and 1858 in conjunction with Dr. Dupré, and in conjunction with Dr. Barnes at the same time, who was then medical officer of the "Dreadnought" hospital. I was also engaged in 1868 and 1869 in conjunction with the late Dr. Allen Miller, and I have been engaged in 1881 and 1882 in relation to this inquiry.

16,441. You have heard the evidence given by Dr. Dupré and Sir Frederick Abel, have you not?—Yes, and I entirely concur with what they have said.

16,442. What do you say with respect to the self purifying power of the river?—I say in particular, that I quite agree with what Professor Abel has said, that the self purifying power of the river is in excess of the polluting action of the sewage discharged into it; so that even the worst stretch of river water oscillating above and below the outfalls, does not get so polluted as to be a nuisance.

16,443. How do you consider that fact has been established?—I consider that fact to have been established both by ordinary observation of the river; that as a body of water, it does not smell offensively or look offensively, that there is no evidence to the senses that it is polluted; and secondly, that when we come to examine it by analytical methods, we find that there is no definite body of polluted water which can be distinguished from the general mass of river water, but that starting from Teddington, there is a continuous gradual increase of pollution till you get to the outfalls, and then a gradual decrease of pollution till you get to Southend, when the water, *qua* organic matter, is in exactly the same position as it was at Teddington. The increase and decrease is perfectly continuous, it forms a curve if you take the average of a number of observations. Taking the average of three hot months, July, August, and September 1882, the condition of the water at Erith is such as might result from adding one portion of average sewage, to 27 parts of Teddington water, and at Purfleet such as would be produced by adding one part of average sewage to 49 parts of Teddington water. In other words, the sewage would form a 28th in one place, that is at Erith, and at Purfleet it would produce about one 50th, that is to say, two per cent.

16,444. Now I will ask your opinion shortly as to the chemical processes which have been practised with a view of ascertaining the condition of the river water.

(*Chairman.*) If that is so which you have stated, it must be attributable to the purifying power of the water, because there is no addition of water at all between the two places.

(*Mr. Michael.*) I will come to that in a moment, and the witness will explain how the purification is produced, and the means required for the production of it

(*Witness.*) It has been made a sort of reproach to us that we have not used the combustion process. I would say I have not used the combustion process in this case for the same sort of reason that I should not think of taking a razor to carve a leg of mutton, because the coarser method is better adapted for the purpose, that is to say, the Wanklyn and the permanganate processes. It is not so much a matter of chemistry, as a matter of common sense. If you examine Teddington water by any process you like, and then examine sea water by the same process, and you find they each give you a result which you can call 1, and if you examine sewage by the same process and you find it gives you 28, and if you find a continuous increase up to the outfalls, and after that a continuous decrease, and if you get the same general average result by three independent modes of examination, it is evidence, and cumulative evidence, to show that you have the measure of pollution and purification.

16,445. (*Mr. Michael.*) Even if you adopt the razor for chopping the block, does it do more than tell you the proportion of organic carbon and organic nitrogen which was present in a given sample of water; but does it do more in telling you what the source of that organic carbon and organic nitrogen is than the other processes do?—No, it does not. You may take any process you like; practically if you take the tables handed in by Dr. Tidy, you find that his results as given in his second table show substantially the same thing. He finds that taking the stretch of water from Teddington to Battersea, the organic carbon is ·2, from Vauxhall Bridge to Deptford it is ·3, from Greenwich to the Albert Dock it is ·6, from Beckton to Crossness it is ·7, and from Erith to Purfleet it is also ·7, with rather a smaller hundreth—and beyond that he does not go; but we do, and we see that thence to Southend there is a gradual decrease in the curve. Now I should be glad if the Committee will allow me to call attention to the results brought out by Dr. Frankland. Between October the 28th and November the 11th, there are 40 analyses put in of water examined at Saint Paul's Pier, and upon the same 14 days there are 40 analyses put in of the water at Erith. Now you may examine the whole set, and compare the first ten with the first ten or the last ten with the last ten, or the whole 40 with the other 40, and there is always an excess of organic carbon at Saint Paul's Pier as compared with what there is at Erith. Then Dr. Frankland is asked in his examination with regard to this, and he says the water at Saint Paul's Pier at that time contained no appreciable trace of sewage; from which it would follow, if we are to depend upon these analyses, that there must have been a minus quantity of sewage at Erith. Now the mean of the 40 results, at Saint Paul's Pier, upon the days between October the 28th and November the 11th, is ·503, and the mean of the 40 results obtained at the same time at Erith is ·400 of organic carbon in 100,000 parts of water.

16,446. (*Chairman.*) You say it shows that if there is nothing at Saint Paul's wharf, there is less than nothing at Erith?—Yes, that is the deduction to be drawn from the figures and statement I have just quoted.

16,447. This must be susceptible of some explanation, because of course it cannot be so—do you impeach his accuracy as to Saint Paul's wharf?—I impeach the accuracy of the interpretation, because I say there must have been sewage, or something in the nature of sewage at Saint Paul's wharf.

16,448. What is the meaning of that decimal figure?—It means carbon, which is the most marked ingredient of organic matter. If you estimate the organic carbon, you get an approximation to the amount of organic matter; I may say that the organic carbon in Teddington water is ·25, and at Saint Paul's Pier it is double; nevertheless there is the remarkable fact, that during these 14 days in which the river was in flood, there was absolutely a less amount of organic carbon at Erith, than there was at Saint Paul's Pier.

16,449. It is impossible that there may be something of this carbon in the water which is not attributable to organic matter or sewage?—There can be no carbon estimated by this process but what is attributable to organic matter. Of course organic matter might be got in from other sources than sewage, but having regard to the large amount of sewage matter that gets in, one would naturally attribute it to the sewage.

16,450. You think that the ·5 does indicate the presence of sewage?—Yes, I do.

16,451. Although Dr. Frankland said it did not?—Although he said not.

16,452. (*Dr. Stevenson.*) This was during flood time, was it not?—It was during flood time.

16,543. Did you ascertain whether the overflows were acting at that time?—I do not know for a fact whether they were or not.

(*Mr. Michael.*) It may be taken that they were, because at all times of flood they act; they exist for that express purpose, and they act automatically. When the water rises above a certain height, they must act, because the water must go over the weir.

(*Witness.*) But it has been given in evidence over and over again, that the water above Bridge is never very reprehensible.

16,454. (*Mr. Michael.*) Does the pollution of even the worst stretch of water become excessive at any time?—It does not.

16,455. What do you think that is due to?—It is partly due to dilution, and partly to the destruction or oxidation of the sewage matter. With regard to this matter of oxidation, I should like to point out to the Commission that, supposing you take the normal proportion of oxygen in water not at two cubic inches per gallon, but at something less, at 1·84 cubic inches per gallon; upon that calculation every four million cubic feet of water would contain one ton. Now here we are not dealing with four million cubic feet, but with 2,000 or 3,000 million cubic feet carried forward at a tide; therefore we have several hundred tons of oxygen to play with.

16,456. What do you take as the mean proportion of free oxygen in the flood water at Erith?—According to our experiments, the proportion of oxygen in the flood water at Erith is reduced to about one-fourth of its normal amount, which means to say that it has expended three-fourths of its oxygen in doing something or other, in other words, in oxidising sewage; it must be that, because there is nothing else to oxidise.

16,457. (*Chairman.*) Will you allow me to ask you, because it seems very important, at what time of the tide did you take the water which you say has lost three-fourths of its oxygen?—This was the average of a series of experiments made upon the rise of the tide, which were put in evidence by Dr. Dupré, who showed you the curve they gave.

16,458. (*Sir John Coode.*) What, can you tell us, is the proportion of oxygen in salt water as compared with that in fresh water?—It is a somewhat smaller proportion; if you take fresh water at two cubic inches, it is about 1·8 that is a little less in salt water; but for the purpose of this inquiry it is practically the same. Now, if you take the quantity of flood water passing Erith upon a single tide to be 3,200 million cubic feet, and Mr. Mansergh gave it at 3,500 million cubic feet, you will find that that water actually contains 200 tons of oxygen which it has to expend, and it must have already expended 600 tons of oxygen, and having expended that 600 tons of oxygen, it must have oxidised several hundred tons of organic matter.

16,459. That is to say, it had originally 800 tons of oxygen, and had expended 600 tons, leaving 200 tons in the water?—Yes; and that would be disregarding all the oxygen contained in the river above Erith at low water.

16,460. How much sewage would the amount of oxygen remaining in the water suffice to oxidise and destroy?—You may take it that 200 tons of oxygen being sent up with the flood tide would suffice, at any rate, to oxidise over 100 tons of organic matter, while the quantity of organic matter put in at any single tide is about 50 tons.

16,461. So that you have always something more than is required to oxidise what is put in?—Yes.

16,462. That would account for the sewage not creating a nuisance in your opinion?—To a very great extent, no doubt.

16,463. (*Chairman.*) Do I understand you to mean that when the water reaches Erith it is already short of that quantity of oxygen which would be in it if it were not the return water which had already oxidised some sewage?—Yes.

16,464. When it comes back it has still enough oxygen in it to do the work that is required of it three or four times over?—Yes.

16,465. (*Mr. Michael.*) It meets with organic matter still remaining in the water, and has still left in it oxygen sufficient to do the work over and over again?—Yes; and as the effect of that, we sometimes find the oxygen reduced to about one-tenth.

16,466. (*Chairman.*) To about a tenth of what would naturally be there?—Yes.

16,467. (*Dr. Stevenson.*) Does sea-water part with its oxygen as readily for the purpose of oxidising organic matter as fresh water?—There is no reason to suppose that it does not. I do not know of any direct experiments in the matter, but that is my impression.

16,468. (*Mr. Michael.*) But you have found that the oxygen has, to a large extent, gone out of this water, which is salt water merely mixed with a large amount of upland water?—Yes, that is so.

16,469. And that the action of the oxygen must have prevented putrescence from taking place?—Yes.

16,470. There has been a certain oxidation occurring which has prevented bad results from following?—Yes.

16,471. (*Dr. Stevenson.*) We have no evidence as to how long the oxygen which has disappeared from the water has taken in disappearing?—No; the only sort of facts we have are, that there is the fresh water coming down which has about two cubic inches of oxygen per gallon—there is the sea water coming up with about its two cubic inches per gallon. Then you have a stretch of intermediate water in which you find the proportion very much less, as, for example, at Erith, where it is about one-fourth, that is to say, each gallon contains half an inch instead of two cubic inches.

16,472. Would not that seem that there is a very large proportion of organic matter below Erith to oxidise?—It would show that there was organic matter there being destroyed faster than the water could fully saturate itself with oxygen.

16,473. Below Erith?—Yes.

16,474. (*Mr. Michael.*) There of course you have continuously coming up water fully charged with oxygen to meet the wants of the water coming down which has been to a large extent deprived of its oxygen?—Yes, establishing an equilibrium.

16,475. Of course there might be such an amount of organic matter pouring into the river, that the water coming up would be inefficient to do its work?—Yes.

16,476. But that has not happened?—No; that is not the case yet.

16,477. (*Sir John Coode.*) Have you made experiments upon the quantity of oxygen in the water at high water before the sluices are opened, in order to ascertain that the sea water coming up has its full proportion of oxygen? The thought that occurs to my mind is, whether the water being left in the river deprived of its due proportion of oxygen, the sea water coming in is not deprived of its proportion of oxygen to supply the deficiency of oxygen in the water in the river before the tide comes up?—I have no doubt that is so.

16,478. Have you ever made any experiments upon the water in the river at high water before the sewage has come in?—Tables were put in by Dr. Dupré to show that. I am referring to page 66, Table 4*a* of his Tables.

16,479. (*Dr. de Chaumont.*) Are you of opinion that the power of oxidation is diminished when the amount of oxygen is diminished in the water, in a greater degree than in the proportion of the diminution of the quantity of oxygen. We have had it stated that when there was two of oxygen in the water and that was diminished to 1·5, the loss was more than in the *ratio* of 4 to 3—is that the case?—That evidence was given by Dr. Tidy. I should say we have considered that, and that my colleagues Sir Frederick Abel and Dr. Dupré, are of opinion that that is not so.

*Dr. W. Odling, F.R.S.*

26 June 1883.

I do not go quite so far as they do. I admit there are some facts which are in favour of that theory, and some facts which are opposed to it. I should think it is quite an arguable question. I should think that with the reduction of the proportion of oxygen, the oxidising power might be diminished in a somewhat more rapid ratio.

16,480. That you attribute to the oxygen being more diluted?—Yes; but I should say that in this case, the question is as follows:—It is stated that if you run sewage into 20 times its volume of water containing two cubic inches of oxygen, you destroy it in the course of a twelve miles run. Now here the question is of running sewage into about 250 times its volume of water containing half an inch instead of two inches; it is 20 times its volume with two inches, and it is 250 times its volume with half an inch.

16,481. (*Mr. Michael.*) There you have a very large surplus as the result of dilution against concentration?—Quite so.

16,482. There is another point I want to ask you about. Are you able to tell the Commission anything as to the power of the water to recharge itself up towards the normal point, when from any accidental cause such as the mixture of sewage, the normal quantity of oxygen has been reduced very largely?—That is a very important point. It is not only the quantity of oxygen in the water which it is able to act with, but the quantity it is capable of absorbing, and the quantity of oxygen it is capable of absorbing from the air is exceedingly great.

16,483. When you have reduced the quantity below the normal quantity, is there a continual tendency on the part of the water to recuperate itself from the air?—There is.

16,484. If there is any vegetation of any kind is that also a cause, especially in sunlight, of oxygen being given off from the surface?—Vegetation is an additional source of oxidation of the water.

16,485. Whether the vegetation be microscopic or otherwise?—Yes. As I have expressed myself so strongly upon this question of oxidation, I should like to make an observation with regard to one of Dr. Frankland's experiments. I should say that Dr. Frankland's experiments upon the oxidation of sewage seem to me to be of two kinds; there are those which prove nothing either one way or the other, because they are not adapted to prove anything, and there are others which prove our case, and amongst those which prove our case, I would call attention to those which are given in detail in the 6th Report of the Rivers Pollution Commission. They amount substantially to this, that he took river water, and mixed the river water with 5 per cent. of sewage; he analysed a portion of the mixture immediately, the rest was put into bottles, and he opened one of the bottles every day. Now at the end of two days Dr. Frankland's statement is, that 16 per cent. of the sewage matter was destroyed; but Dr. Frankland actually put in from four to six times as much sewage as all the oxygen in the bottle could possibly oxidise, and accordingly 16 per cent. of the actual sewage is equivalent to at least 64 per cent. of what could possibly be oxidised. Even 16 per cent. in two days is practical oxidation; but if he had gone further than he did, and put in eight times that amount of sewage, it would only have been two per cent. of oxidation upon his quantity of organic matter, but still there would have been the same actual oxidation.

(*Mr. Balfour Browne.*) Would it not have been better if my learned friends Mr. Bidder and Mr. Michael had put the point to Dr. Frankland.

(*Mr. Michael.*) We put as many points as we could think of.

(*Chairman.*) And very probably they were not aware of it at the time. (*To the witness.*) If you had been present at that time you might have instructed your counsel to correct what you say is a fallacy.

(*Witness.*) If Professor Williamson or Dr. Stevenson will please take down the figures, the oxygen amounted to ·946 in 100,000 parts.

16,486. (*Dr. Stevenson.*) That was the oxygen by weight?—Yes, and the organic carbon in the water was 2·1. Now at a very low reckoning, that would be equivalent to four parts of organic matter, so that you have four parts of organic matter as against less than one part of oxygen. And even if you allow that oxygen is capable of oxidising its own weight of organic matter, still you have in this experiment four times as much as it ought to have been subject to. I say then that even upon Dr. Frankland's explanation, a power of oxidation was manifested, even under those unfavourable circumstances, of 16 per cent. in two days; and I say that that rightly interpreted means 64 per cent in two days.

16,487. (*Chairman.*) If I understand your observation correctly, if it had remained there for a month, there would have been no greater amount of oxidation unless the water had got re-oxidised in some way?—That is so. If you calculate the amount of oxidation effected in percentages of the organic matter, it will depend entirely upon the quantity of organic matter present. The proper way to calculate it is, upon the quantity of oxygen removed, because if you take a certain quantity of organic matter upon which the oxidation comes out at 16 per cent., if you double that amount of organic matter it comes out at 8 per cent., and if you quadruple that amount of organic matter, it will come out at 4 per cent., unless you double or add to the oxygen.

16,488. (*Mr. Michael.*) Does not it come to this, that the oxygen in water is only competent to do its own proper share of work?—Yes.

16,489. Here the oxygen has been doing its work, and that is manifest by the removal of the oxygen?—Yes.

16,490. The atmosphere is constantly tending to restore the quantity of oxygen in the water, and here it is evident that there is sufficient oxygen in the water to renew the oxygen consumed by the sewage stream and to purify it?—Yes.

16,491. Now would you tell me about any smell which is given off by the sewage stream?—In warm weather the smell given off by the discharge of the sewage stream is sometimes offensive and nauseating, but according to my experience, and I have been there frequently in hot weather, it does not spread very far.

16,492. And could it spread a mile from the banks?—According to my experience it does not spread anything like a mile from the banks.

16,493. (*Sir John Coode.*) Could it do injury on the banks?—That has not come within my purview lately; but 25 years ago, I was Medical Officer of Health for Lambeth upon the river side; and in conjunction with Dr. McWilliam who was the Custom House Medical Officer, and Dr. Barnes of the "Dreadnought" and some others, we went carefully into this matter, and as far as we could make out, although the river at that time was smelling, yet there was no substantial increase of disease that one could trace to it in any way.

16,494. (*Chairman.*) What year was that?—It was in 1858 and 1859 before the sewage outfalls were opened, but when the whole mass of water and sewage which then oscillated higher up instead of low down (it oscillated between Greenwich and Westminster more especially) had a most extreme stink, and was more black than brown.

16,495. (*Sir John Coode.*) As I understand, the site of your observations at this time was at or near Lambeth?—Yes, at or near Lambeth, and down to Greenwich.

16,496. Upon the part of the river which was then affected by the sewage?—Yes.

16,497. (*Chairman.*) I should infer from what you say, that the volume of water in the river then was not sufficient to oxidise the sewage?—That is so, we had that borne out by experiments made by Dr. Allen Miller, who found that the quantity of oxygen in the

river was nil, and the colour of the mud was black. As you have been told, when the sewage is oxidised, it turns brown; when it is not oxidised, it turns black.

16,498. If I understand your observations rightly, this sewage could scarcely ever reach Woolwich in an offensive state?—If it is discharged upon the turn of the tide, certainly not.

16,499. But if it were discharged while the tide was still flowing, do you think it could reach Woolwich then in an offensive state?—I should think not, but I have not myself traced it up to Woolwich, the river gets very narrow there, and the sewage might get into eddies and be unpleasant.

(*Mr. Balfour Browne.*) There was evidence from Captain Burstal to the effect that that was so.

16,500. (*Chairman.*) When it gets to Woolwich it has travelled more than two miles along the river?—My clear opinion is, that it would not be offensive; but in the other case I was speaking from observation; whereas here I am only speaking from opinion.

Cross-examined by Mr. Balfour Browne.

16,501. To refer for an instant to the Report you made in 1858, when you were connected with Lambeth, On page 12, I see you say this:—"I am inclined to "think with Mr. Goldsworthy Gurney, that suspended "sewage if thrown into the Thames, no matter how "far down, will be brought up again by the upcast, and "if the retrogrades be not destroyed, it will be retained "in the River." That was the opinion you then came to, that sewage thrown in however far down would come up again?—With a qualification.

16,502. What is the qualification?—"If the retrogrades be not destroyed."

16503. Do you adhere to that?—I am not only of opinion that some sewage matter might get up the river, but I know as a fact, that some does get up at the present time.

16,504. But you are unable to tell his Lordship how far the sewage does get up the river so far as to be injurious?—As I say, it does not get up any distance so as to be injurious.

16,505. You have used the expression that in warm weather it becomes offensive and nauseating; how far up the river would that apply?—I have just stated in answer to his Lordship, that that would not reach so far as Woolwich.

16,506. But that you said was a matter of opinion, and not of observation?—But I can say, speaking from experience, that since the outfalls have been in existence, there has not been any smell in the water above bridge.

16,507. In the Report you have before you, you seem to attribute most of the nauseous smells not to the water itself, but to the exposure of the sewage matter upon the banks of the river, is that so?—That is substantially so, with some qualification. I was speaking then of above London. I believe the chief source of the smell even in those worst times was due to the large deposit of the mud banks which existed in different parts of the river; that those mud banks did not smell so much when they were left quiet, but that with the flow of the tide they were disturbed, and their disturbance in that way created a very considerable nuisance, and was the cause of the blackness of the river.

16,508. You said there, I see upon pages 18 and 19. "No matter at what point of the river the sewage is "discharged, you may rest satisfied, organic mud will "still be deposited upon the exposed flat banks of the "Thames"; is that your opinion now?—In essence, yes. That is to say, if you take the paragraph by itself, it bears the exact interpretion you have given it. But if you take it as a whole, the remedy proposed was increased scour, whereby the mud should not deposit upon the banks, and as a matter of fact, that portion of the bottom of the Thames which is exposed at low water, is no longer mud, but gravel. The banks are substantially clean, whereas before, there were extensive mud banks.

16,509. In that Report you criticised the Main Drainage Scheme. "In this scheme there is taken "down a great deal of natural storm water, which "should be disposed of in another way." Is it not so?—Yes. I should say that the whole purport of this Report was to show, that unless the river were embanked and the scour of the river increased, it was a matter of little consequence where you poured the sewage into it.

16,510. And that is your opinion still?—Substantially it is. I believe that now if you had the same exposure as you formerly had, the sewage water from Barking would be carried higher up the river, and a portion of the mud would be deposited upon those banks, and in hot weather it might become a nuisance but not to so large an extent as when the sewage was discharged higher up the river.

16,511. (*Chairman.*) You thought that these outlets would be as injurious to the river where we are now, as what was then going on?—What I thought was that it would not prove an effective cure.

16,512. Not even up to Westminster Bridge for example?—The tendency of light mud is to deposit with the ebb tide, and then the flood tide coming up stirs that up and carries it forwards, and no doubt there is a liability to some portion of the suspended matter being carried high up the river, unless you have a sufficient scour over the whole surface.

16,513. Do you mean by "suspended matter" the mineral matter?—No, I am speaking of the lighter portion of the suspended matter, which is mainly organic.

16,514. There is a tendency to carry it up, is there?—There is a tendency to carry up a considerable portion of it—of course the thing arrives at a balance in time.

16,515. (*Mr. Balfour Browne.*) If I understand rightly, you expected the river after these works would smell at Westminister Bridge, nearly as badly as it did before?—If you will leave out "nearly as bad," I would say so. My opinion is, and was, that there would be an appreciable quantity of mud brought up unless the scour of the river was increased.

16,516. Do you think there is now?—No, because we have an increased scour by means of the embankment.

16,517. How far does the Thames Embankment affect the Thames in London?—We have all that long piece of ground now covered by the embankment which was formerly mud bank.

15,518. But we have mud banks upon the Lambeth side still?—Yes there are some, but they are very small compared to what they were. Formerly if you dredged the river bottom it was mainly mud, now mud is the exception, and if you dredge now you find gravel.

16,519. Do not you think that unpolluted rain water ought to get in the river—for instance the rain water falling on London should get into the river in London, and not be carried down by an expensive aqueduct to Barking?—I do not think there any use in carrying the rain water to Barking if you could find an economical way of discharging it higher up.

(*Chairman to Mr. Balfour Browne.*) It seems to me that the drift of your cross-examination is to show that Dr. Odling was mistaken.

(*Mr. Balfour Browne.*) No, my Lord, I think he was right—that he was entirely right then, and wrong now.

(*Chairman.*) That is to say, he anticipated a continuation of the nuisance up the river here.

(*Mr. Balfour Browne.*) Yes.

(*Chairman.*) I understand you to say that he thinks there is one still, but not appreciable hardly.

(*Mr. Balfour Browne.*) That is so.

(*Chairman.*) Do you want to make it out to be appreciable.

*Dr. W. Odling, F.R.S.*

6 June 1883.

(*Mr. Balfour Browne.*) I did not expect Dr. Odling to admit that it was appreciable.

(*Chairman.*) But what does it matter, suppose he was wrong, I believe everybody here is of opinion, with all due submission to Dr. Odling, that he was wrong, because people are bathing in the water between the bridges. I do not know whether they purify it in any way at those baths at Charing Cross.

(*Witness.*) My opinion was that, unless you embanked the river, you would have those difficulties. The river is embanked, and the difficulties have disappeared.

(*Mr. Balfour Browne.*) But the river is not embanked throughout the whole length of London, but only for a very small piece; and you tell the Committee that wherever you have these mud banks, the deposit will take place, and will become offensive.

(*Chairman.*) I cannot see the use of it, because if Dr. Odling were to say that the river was as bad now as it was in 1857, I should respectfully hold my tongue, though I might withhold my opinion also.

(*Mr. Balfour Browne.*) Dr. Odling says that wherever you find mud banks, you find a deposit of organic mud which will become offensive; he now assumes for the purpose of his argument, that the Thames has been all embanked through London, whereas it is only partially embanked, and there are mud banks.

(*Mr. Beaumont Morice.*) And with regard to the baths I am told the water is filtered through charcoal filters.

(*Chairman.*) Would filtration take away the smell.

(*Witness.*) It would if you filtered it through animal charcoal.

(*Mr. Beaumont Morice.*) And that is what I am informed is done.

(*Witness.*) With regard to the mud, is all a question of degree. When there is a very large mass of mud upon the banks, it makes the river smell. When it is in small proportion, it is no more than the river can manage.

16,520. (*Mr. Balfour Browne.*) Would you say it is essential for the public health that the mud banks should be removed?—I say the mud banks are really so small in comparison to the mud banks which previously existed, that it is quite in the power of the river to overcome their polluting influence, which formerly was not the case, because we know the river above bridge stank.

16,521. It is your experience, I think, that the temperature of the mud banks is very much higher than that of the water?—Of course when the sun is shining upon them it is so.

16,522. And of course that leads to the rapid putrefaction of the matter upon the mud banks?—Yes; the higher the temperature, the more rapidly putrefactive change goes on.

16,523. What was the temperature of the mud banks; was it 120 degrees as compared with 70 degrees in the water. I think you stated it when you were giving evidence before the Commission as to the embankment of the River Thames?—I think that must have been a slip, 120 degrees is very high. I think it must have been either a slip on my part or a slip in the report.

16,524. I have here, "During the hot weather, the "temperature gets as high as 120 degrees, while that "of the river water is not above 70, and it is always "in such times that the smells are most unpleasant"?—It is quite possible that the mud should get to a temperature of 120 degrees with the sun shining upon it.

16,525. Is it your experience that the river does not get so well aerated in hot weather, as in cold?—I think that is the case.

16,526. And in that Report, as you told the Commission, you found that the water between Greenwich and Chelsea was very offensive?—In that year it was very offensive, and in the year preceding to a somewhat less extent.

16,527. When I am speaking of your evidence, I am speaking of your evidence given in the year 1861?—That I cannot call to mind.

16,528. You also gave evidence before the Committee which sat upon the Essex Reclamation Bill?—Yes, I think I did.

16,529. And that was after the outfalls had been opened of course. It was in the year 1865, and the outfalls were opened in 1864, do you remember that?—I dare say that was so.

16,530. Does this correctly express your view now, as it did then: "I have all along been of opinion, "and have expressed it many times, that the discharge "of sewage at Barking will not be sufficient. I know "that there are great authorities upon the other side, "but that is my individual opinion." Is that your opinion still, as it was in the year 1865?—Yes; because I had in view then the necessity of an increased scour of the river to supplement that. At that time the embankment was not made.

16,531. Personally you know nothing about the scour of the river, you are taking that from the engineers, I presume?—I was very much engaged with engineers when that inquiry took place, in some experiments which were made as to the rate of flow which was necessary to get a gravel or sandy surface, as compared with a muddy surface.

(*Chairman.*) Dr. Odling was called in that year. I have no doubt that like everybody else who does his duty well towards those for whom he was concerned, he had a bias, though an unconscious one, in their favour. No counsel ever does his duty well unless he is strongly of opinion in favour of his client. Then Dr. Odling ventured upon what we may call an opinion, not as to an actual matter upon which he could employ his skill, but a speculative opinion as to the future. In my humble judgment he was wrong, unless it is, as he says, that but for the additional scour he might have been right; but after all what do you prove upon that.

(*Mr. Balfour Browne.*) There is an entire distinction, I submit, between the advocate who has strong views that his clients are right, and a skilled witness who comes to instruct the Committee upon matters of fact. Dr. Odling was called as a skilled witness.

(*Chairman.*) But suppose he was wrong then.

16,532. (*Mr. Balfour Browne.*) I should be glad if he would say the same thing again. (*To the witness.*) But even now has the Thames Embankment increased the scour at Barking?—At Barking, the condition of things is entirely different.

(*Chairman.*) Suppose he were to say, "My anticipations have not been realized, either because I "was wrong in my opinion, or because the additional "scour or something else has obviated those bad "effects which I anticipated;" suppose he was to say that to you, how would it advance the case?

(*Mr. Balfour Browne.*) I think it would advance the case in this way, that you might think he was wrong again.

16,533. (*Chairman to the witness.*) I daresay you will admit, that like the rest of us, you have been wrong a good many times in the course of your life?—No doubt.

16,534. (*Mr. Balfour Browne.*) You said your opinion was that the discharge at Barking never would be sufficient to purify the river?—That was my evidence, and as a matter of fact something else was done in consequence.

16,535. You say now that the increased scour has altered those circumstances?—Yes, it has in the upper Thames.

16,536. Has the increased scour affected Barking one whit?—I do not know that it has, but you put in my hand a report referring to the upper river.

16,537. But this statement referred to Barking: "I have all along been of opinion, and have expressed "it many times, that the discharge of sewage at

"Barking will not be sufficient"?—"Will not be sufficient to purify the upper Thames."

16,538. You say it has not affected the condition of things at Barking?—No, but it has affected the condition of things in the upper river to which alone the question applied.

16,539. (*Mr. Balfour Browne.*) After what your Lordship has said, I will not pursue the question any further. I think Dr. Odling's admission is sufficient (*To the witness*). But I am told to ask you this, in your experiments have you traced the sea water as high up as Wandsworth?—Yes, I have.

16,540. (*Chairman.*) When was that?—It was 20 years ago.

16,541. (*Mr. Balfour Browne.*) And you also said "where the sea water would get, I believe the sewage would get back?—Yes.

16,542. Now about these chemical processes, you use the organic carbon process yourself?—Yes, I do.

16,543. In this case, have you made any analysis separately from the other chemists?—I have made one series of analyses.

16,544. Were they made with the organic carbon process?—They were.

16,545. Why were they not put in?—I have them in my pocket, they were made to check the analyses of the other side, and they come out substantially the same.

16,546. Have you ever tested the oxygen process in salt water?—I took part in the experiments which were made by Dr. Dupré, but only a minor part.

16,547. You did some part of that experiment?—Yes.

16,548. But with the exception of that, you never have tried the oxygen process in sea water?—No.

16,549. As I understand, you do say that the combustion process is a better instrument than either the permanganate or Dr. Wanklyn's process?—It is a better instrument for certain purposes.

16,550. It tells you a good deal more than either of those other processes would?—It tells you something different.

16,551. "A good deal more" is my question?—You cannot say more or less with regard to things which are irrelative; but with regard to this particular case I should like to say that it is really a question not of chemistry but of common sense. If you have any measure whatever, and apply that to Teddington water and to sea water, and find that you get a result which you may call 1, and if you then apply that to sewage and get a result which you may call 28, and you find when you apply that to river water which is a mixture of the two, that there is a gradual increase to where the sewage is discharged and a decrease from that point downwards, it does not matter for the value of the thing whether you get an absolute result; unless the measure shifts its size, it does not matter in the slightest degree.

16,552. You have not made any test with the albuminoid ammonia process?—I have not myself.

16,553. As far as the chemical evidence is concerned, that is the only evidence you can give?—No, I have been concerned with the chemists all along.

16,554. I think that what you have handed to me, (*witness's results by the organic carbon process*) supports the evidence that was given both by Dr. Frankland and by Dr. Tidy?—It is quite in harmony with the general evidence.

16,555. Now as to oxygen being taken out of the water, as I understand you find that at Erith there is a fourth of the entire amount of oxygen left in the water?—Yes, 200 tons.

16,556. 600 tons having been burnt up, as you say, in doing the work of destroying the sewage?—Quite so.

16,557. That is at Erith?—Yes.

16,558. Then did I understand you to say that the incoming tide brings up water with the normal amount of oxygen in it, 1·8 or 1·9?—I never said that.

16,559. I thought you said it was replaced by water having the normal amount of oxygen in it—do you mean that the supply of oxygen was kept up by the sea water coming in?—All I say is, that there is a body of water passing Erith twice a day, and that that body is charged to the extent of 200 tons of oxygen, and that that is about one-fourth of what the normal proportion of oxygen should be.

16,560. At that point there may be an amount of sewage still to be burnt up, using up that 200 tons?—Capable of using it.

16,561. (*Chairman.*) As I understand you, not even capable of using it. What I understood you to say was, that the return water at Erith has lost three-fourths of its oxygen?—Yes, that is so.

16,562. But that the fourth that remains is capable three times over of burning up the amount of sewage that would be poured into it from the two outfalls?—That is so.

(*Mr. Michael.*) That is in short the whole matter.

16,563. (*Chairman.*) You admit that the return water, which I will not call "fouled," has been operated upon by the sewage to the extent of having three-fourths of its oxygen taken from it?—Yes.

16,564. (*Mr. Balfour Browne.*) Under those circumstances the sewage which has come out of the outfalls in the past has eaten up three-fourths of the available oxygen in the water?—Yes.

16,565. Under those circumstances how can you say that the 200 tons, that is the one-fourth which is left, is capable of disposing of the sewage coming out of the outfalls after the previous sewage has disposed of three-fourths.

(*Chairman.*) He does not say that the three-fourths had been taken out by the previous discharge of sewage, but that discharge after discharge having been mixed with the river water, upon each return of the tide, he finds it deficient in three-fourths of its oxygen but having the one-fourth in it.

(*Mr. Balfour Browne.*) If so, there could be no sewage in the water, because if the 600 tons is capable of eating up all the sewage in the water at once, there could be no deficit. (*To the Witness.*) Now in your table you assume 200 tons in the low water which has to come up the river—this is when it comes up the river. Now look at your own table at page 68, instead of being one-fourth here, I find that at one point you give the cubic inches of oxygen, not at one-fourth part, but at one-twelfth part.

(*Chairman.*) Where is that?

(*Mr. Balfour Browne.*) At low water. And that is the water which he says is pushed up by the tidal water.

(*Chairman.*) No, the witness takes the average.

(*Witness.*) It varies from 10 per cent. up to over 40 per cent., and we have taken it at 25 per cent. as the average.

16,566. (*Mr. Balfour Browne.*) But at certain periods, it is as low as 10 or 12 per cent.?—Yes, and at certain periods it is as high as 42 per cent.

16,567. It is that low water which is in the river when the oxygen is one-twelfth part, which goes up and meets the sewage?—I do not follow you.

16,568. It is not that water which goes up and is pushed by the tidal wave past the outfalls into which the sewage is discharged?—Yes, with a great mass of sea water in addition.

16,568. Is it your impression that fresh sea water comes from Southend every tide?—Some does.

16,570. That is your impression?—I know it.

16,571. Are you giving your evidence under the impression that sea water comes from Southend past the Barking outfalls every tide?—The great mass of course does not, but some does.

(*Chairman.*) I do not know that the witness is giving his evidence under that impression. He says he has ascertained that on the average the water which passes Erith upwards has lost three-fourths of its oxygen, but has got the other fourth.

(*Mr. Balfour Browne.*) But I asked him whether, taking it at the worst condition, that was not the water which would pass the outfalls, and he says

*Dr. W. Odling, F.R.S.*

26 June 1883.

yes, that water with some fresh water which has come into the river at Southend.

(*Witness.*) I said, with the great body of brackish water which exists all the way from Southend to Erith.

(*Chairman.*) I suppose the water which is off Erith at low water, in all probability, at high water has got above Greenwich.

(*Mr. Balfour Browne.*) The oscillation is just 12 miles.

(*Chairman.*) It is not into that water alone that the new sewage is discharged, but it is discharged into that which has come up during the five hours upward tide.

16,572. (*Mr. Balfour Browne.*) Yes, the sewage is discharged into water which received at any rate a portion of the previous discharge. (*To the witness.*) Now let me ask you another question with regard to that. I did not catch what your answer was to the question put by Dr. de Chaumont. Is it the fact that in consequence of dilution, the oxygen looses its power?—I said that there were some facts which rendered it probable that it was so—and that there were other facts which were opposed to that—that my colleagues, Sir Frederick Abel and Dr. Dupré, came to the conclusion that its power was not diminished disproportionately. I did not give an opinion on the one side or the other, but I said that it might be.

16,573. With regard to the oxygen, is it your opinion that much oxygen is taken up directly by water from the atmosphere?—Undoubtedly.

16,574. Is it not the fact that in rivers a large portion of the oxygen is got from vegetation?—It must be; but when a river is like the Thames at Teddington, fully saturated, it cannot take up any more.

16,575. But below Teddington there is no vegetation to supply any void that may be made by the sewage, is there?—Yes, there is a great amount of such growths as diatoms.

16,576. Do you think that they add anything in the way of oxygen?—I do not know anything about that practically; but I know if you pour water through the air you will get it absorbing oxygen most rapidly.

16,577. Is not the oxygen absorbed from vegetation the most active form of oxygen?—It has been stated, but I do not know whether it has been established, that the oxygen given off by plants is in a more active state.

16,578. You do not dispute it, do you?—I neither admit it, nor dispute it.

16,579. Now Dr. Frankland's experiments are given in the 6th Report of the Rivers Pollution Commission?—Yes, they are.

16,580. You have known of them for some years?—Yes, I have.

16,581. You were aware of them, were you not, when you gave evidence upon the Cheltenham Water Bill in 1879?—I was aware that they had been made.

16,582. And the question there was as to the pouring of the sewage from the town of Tewkesbury into the River Severn?—I may say that I was reading over Dr. Frankland's evidence upon this matter the day before yesterday, and it was only then that I came upon the point I have made to-day.

16,583. But you then followed Dr. Frankland in giving evidence as to the Severn as a source of supply upon to the town of Cheltenham?—I may have.

16,584. Those experiments were referred to by Dr. Frankland in his evidence in the Cheltenham case, and you did not then take any exception to them?—I did not. I never found out their flaw really until the day before yesterday.

16,585. But you came and said you agreed with Dr. Frankland upon that occasion. Now let me ask you this, did you not in that case say that it required a very long flow of a river to dispose of sewage?—If you will give me the question and answer, I can tell you. I do not remember it otherwise. My experience and my belief is that it does not require a very long flow.

16,586. Do you remember Dr. Frankland repeating what he had said before, that no river in England was long enough to dispose of sewage?—I do not know whether he said that, if he did, I do not agree with him.

(*Chairman.*) Did not somebody cross-examine Dr. Tidy for the purpose of showing that he had said that in a very short course the river ran itself pure.

(*Mr. Michael.*) Yes.

(*Chairman.*) The result of this cross-examination is to show that Dr. Odling has said something upon a former occasion inconsistent with what he says now. Surely we may rely upon Dr. Tidy's evidence upon this matter, that the water would purify itself.

(*Witness.*) I have never said anything inconsistent with that.

(*Mr. Michael.*) The question in the Cheltenham case was taking the River Severn into Cheltenham to supplement the supply which was then given to Tewkesbury from Cheltenham; and the question was whether it could be taken into Tewkesbury in a fit state.

15,587. (*Chairman.*) Did you say it was not fit?—I do not remember.

(*Mr. Balfour Browne.*) Dr. Odling distinctly said it was not fit. The whole question turned upon this, whether the river in running down from Tewkesbury, where it took the sewage to Cheltenham, where they took the water from it, had not disposed in the interval of all the sewage.

(*Chairman.*) I cannot help reminding you of what was said by Professor Abel. I asked him whether he thought the water would be fit to drink after it had run 20 miles, and he said, no, I can say that the offensive smells would be done away with, but I cannot say the water would be fit to drink.

(*Mr. Balfour Browne.*) I was not asking whether the water would be fit to drink, but whether in a certain flow it would be purified to a certain degree.

(*Chairman.*) The evidence is not that the sewage is annihilated altogether, but that the offensive parts are rendered inoffensive by conversion into different substances.

(*Mr. Michael.*) The whole matter turned upon this, not as to the chemical destruction, but as to the survival of certain germs which have a tendency to create disease.

(*Mr. Balfour Browne.*) I beg your pardon, it had to do with the chemical destruction by oxidisation.

(*Colonel Ewart.*) And the conditions of one river would differ from the conditions of another as to the width, and whether there were weirs, and also as to the vegetation upon the banks.

16,588. (*Mr. Balfour Browne to the witness.*) Do you think that a running river such as the Severn, with vegetation in it, and which is ærated by weirs and other matters of that sort, would be more likely to dispose of the sewage than a tidal river such as the Thames?—I do.

Cross-examined by Mr. Beaumont Morice.

16,589. You stated that you could not tell how far the sewage smell extended; how far did you go down for the purpose?—I have been there repeatedly in the last year or two, and also some years ago in 1868 and 1869, and my experience certainly is that you cannot recognise the smell from the sewage a quarter of a mile off.

(*Chairman.*) I think we are fairly entitled to say we can only allow one cross-examination as to the same matter. I rather think you represent Erith more particularly.

(*Mr. Beaumont Morice.*) I do.

(*Chairman.*) If there were anything relating relating to Erith particularly, you will be entitled to ask as to it, but not to cross-examine as to the question generally.

Examined by the COMMISSION.

16,590. (*Dr. Stevenson.*) I think we have had it stated, I do not know whether in evidence or not, that the discharge of sewage into salt water creates a greater smell or nuisance than if it is discharged into fresh river water; do you know anything about that?—I do not know anything about it definitely, but if sewage is discharged into sea water in sufficient quantity to be putrefactive, I should think it probable that the nuisance would be greater in sea water than in fresh water.

16,591. Do you think that the large amount of salt in the water at Barking and Crossness, where there is from half sea water to a sixth or a third, would retard the putrefaction?—I think it would retard the putrefaction, but I see no evidence to think that it would retard the oxidation. At the same time I do not call to mind any definite experiments upon which I should form that opinion. I only speak from a general impression.

*Dr. W. Odling, F.R.S.*

26 June 1883.

The witness withdrew.

Mr. HENRY CLIFTON SORBY, LL.D., F.R.S., called in; examined by Mr. MICHAEL.

*Mr. H. C. Sorby, LL.D., F.R.S.*

(*Mr. Michael.*) I propose to put in a report made by Dr. Sorby which contains his evidence, and I then can take his evidence very much more shortly than I could otherwise. (*Copies of the report were handed in. See Appendix CB.*) I propose only to give you a summary of the mode he has adopted, and the results he has arrived at.

(*Chairman.*) It is the only mode in my opinion in which to give this class of evidence to us, and as a justification of these details for it is impossible to carry in our minds all the details.

16,592. You are a Fellow of the Royal Society and of a great many other Societies, and you have devoted a great deal of attention, have you not, to microscopic inquiries?—Yes, for more than 25 years; and I may say that I believe I am acknowledged as being the first person who applied the microscope to the definite structure of rocks, and to the structure of loose deposits, like sand and mud, for geological and other purposes.

16,593. When did you undertake an inquiry into the mud, and the deposits which are to be found in the water of the River Thames?—I think it is three years ago, at the time of the inquiry into the origin of the Crossness banks.

16,594. You have devoted a considerable amount of attention to the subject, have you not?—Yes, as much as my time would permit.

16,595. Since that time, in 1882, I think you have lived for many months upon the river, investigating the matter?—A number of specimens were supplied to me by the Metropolitan Board of Works, about the middle of March, and I studied them until about the first week in July, when I came to the conclusion that it was very unwise indeed to rely upon the study of specimens, which I had not collected myself. There were certain questions I could not at all understand, and I thought it would be far more satisfactory to come up in my yacht, in which I live for a great part of the summer up the Thames, and carry on my investigations in my own way.

16,596. And day and night during the warm part of the year you lived off Erith?—I lived for a month off Greenhithe, and studied the river there, and I then came up to Erith and stayed there a month, never sleeping on shore a single night, but carrying out my investigations in the yacht or in a boat.

16,597. This year have you done the same thing?—I have been a fortnight at Erith, and a fortnight at Greenhithe.

16,598. I am glad to see you are not destroyed; did living at those places injure your health in any way?—Not in the least; there is not one of my crew who has the slightest fault to find with the river.

16,599. Do you use the water of the Thames at Erith?—We do not use it to cook with.

16,600. But for any purposes?—Yes, for washing the decks and other purposes; the only objection is when we are close to the tide edge, where there is the sort of scum which always comes down the river; we use the water at other times for washing the decks.

16,601. Will you tell the Commission, shortly, what was the problem which you addressed yourself to solve, what was the object of your inquiries, what did you endeavour to do first?—In the first instance, I examined a series of specimens collected from Hammersmith, right away to Gravesend.

16,602. What sort of specimens were they?—They were specimens of mud deposited from the water. I have not in any way studied the soluble materials of the river.

16,603. Do you mean that you took water, and allowed it to deposit?—Yes, I took water and allowed it to deposit, and then that mud was investigated by the microscope.

16,604. Have you an apparatus by which you are enabled, through very small meshes, about 120 to the inch, to pass 50 gallons of water, and catch the whole of the suspended matter in that 50 gallons?—Yes, but that apparatus was not used until within the last six weeks, my investigations last year were conducted by another method altogether.

16,605. You endeavoured to find all the matters which are held in suspension in the water?—Yes.

16,606. And also you directed your attention, did you not, to the various muds which are found at various sites all the way down the river?—My principal inquiry has had reference to muds held in suspension. I examined some mud at the side of the river, but I was very soon convinced that an examination of those muds could not be carried on unless you collected the specimens for yourself; because the character of the mud upon the surface is entirely different to what it is half an inch or an inch below the surface, and you require to know exactly where it comes from.

16,607. What is the difference as regards the surface of the mud, and what does it arise from?—In some cases the surface of the mud is old material which has been exposed and oxidized, and that I think we need not regard. But the mud I have especially studied is that which has been recently deposited upon the surface; and I found by studying that, that it is materially different from what you meet with one or two inches below.

16,608. In what does it differ; is there any vegetation upon the surface?—It is a very complicated question; but at Erith I have remarked very commonly upon the surface that you have a very large number of desmids and diatoms.

16,609. What are they?—Desmids are as it were diatoms which have not silicious coverings. Those desmids and diatoms and conferva, which abound in the river, are well-recognized plants, about which there can be no kind of doubt.

16,610. Either maritime or fresh water?—Yes, living in fresh or brackish water.

16,611. Have you found a large number of those in your observations?—I may say the brown colour of the mud upon the surface (the Commission will remember that the mud has been described as being of a disagreeable black or dark brown colour) is due to the countless thousands of desmids and diatoms. I may say I have collected the mud and kept it in glass beakers, and you can see that those little plants do not like to be below the surface; they wriggle up to the top, and there they multiply. I find clearly that the brown material you get upon the surface of the mud is entirely composed of desmids and diatoms.

*Mr. H. C. Sorby, LL.D., F.R.S.*

26 June 1883.

16,612. Those little matters, though they are plants, have means of motion; they attach themselves to the surface, which better suits their habits?—Yes.

16,613. Have they any influence upon the oxygen of the water?—Yes, they contain a large amount of chlorophyll. I have for many years paid attention to the colouring matter of animals and plants by means of the spectrum-microscope, and I find that those desmids and diatoms contain colouring matter of certain groups of algæ. Although they do not look green in their natural condition, you can dissolve out the yellow colouring matter, and then leave the diatoms as green as any plant you could wish to see. The number of those upon the mud and in the river is enormous at particular times of the year, and algæ and all plants, when exposed to the sunlight, give off a considerable amount of oxygen.

16,614. You have directed your attention, have you not, to ascertain whether you could discover by the microscope the quantity of sewage matter which was in the suspended matter of the water or in the mud?—The plan I have adopted is to a very large extent new. I do not know that the microscope has ever been employed in a definite manner for quantitative work of that kind until I employed it in the case of the Crossness Bank; and I may say that by employing that method, in the course of a few days I came to almost exactly the same conclusion with regard to the origin of the Crossness Bank as that which the arbitrators came to after holding their inquiry.

16,615. Will you explain the mode you adopted in order to determine what were the characteristics of the suspended matter in the water?—Do you mean with regard to the mineral or with regard to the sewage matter?

16,616. I refer to the sewage matter?—The plan I have adopted is very simple, though, strange to say, as far as I am aware, it has not been adopted before; it was to ascertain what might be looked upon as the characteristic materials of the sewage, that is to say, substances which are not found in the mud of rivers, which are in no way contaminated by sewage. I have drawn a few diagrams just roughly to illustrate my meaning (*a coloured diagram was exhibited*). That is a diagram to illustrate what I will assume to be pure mud, with no sewage contamination whatever. In that we have a number of objects, but none of those which are specially characteristic of sewage. I suppose that to be entirely mud, and nothing else. I will explain the method I have pursued, in which I adopted manipulations which I need not, perhaps, explain in detail, because it would occupy too much time. I may say, that I have the means of determining, by counting the number of different objects, in an equal volume of different material. I know, by suitable experiments, the density of those different materials, and therefore I am able to calculate what would be the number of those different objects in a given weight, which I call "the unit by weight." I then find the most characteristic objects in sewage matter, which are, in the first place, those which are characteristic of the road drift, and the materials derived from the droppings of horses.

(*Chairman.*) Must we not give Dr. Sorby credit for investigating the thing properly unless he is cross-examined to it, and let him tell us his results without giving us the details of his process.

16,617. (*Mr. Michael.*) It is an entirely new mode of investigation, and I tell your Lordship I will take it as shortly as possible, to enable the Commission to understand his method. (*To the witness.*) What are the special matters you have looked for in sewage?—I have taken first, as being characteristic of sewage, the road drift, and the material derived from the droppings of horses, and the most characteristic features that I find are the hairs of oats. I show in this report that the character of the road drift in London can be very well expressed in terms of the washing of the droppings of horses and the ordinary mud, that is derived from the disintegration of the road. I have found upon the average that the horse droppings contain a great number of the characteristic objects which are given by sewage.

16,618. With regard to the sewage matter, that contains a certain amount of human excrement necessarily?—Undoubtedly, and I have directed special attention to the determination quantitatively of the amount of detritus of human fœces. I have described in this report the manner in which I have studied human fœces, and I would say that what I call a unit of human fœces, contains a large portion of undigested muscular tissue, from the meat consumed, for example; and with regard to that I may point out what is important, viz., that the undigested muscular tissue which is found in that human fœces is not in the condition in which it is found in roasted flesh, it has undergone such a process that you cannot digest it successfully by a warm acid solution of pepsine in which you can easily digest cooked meat. Those fibres which form a part of the human fœces are not to be acted upon by that, and they resist also the action of dilute caustic potash.

(*Chairman.*) Is this witness going to show that there is, or is not, any sewage is mud.

16,619. (*Mr. Michael.*) The witness is going to show, according to his process, the nature of the mud all the way from Teddington to Southend, but I will take it shortly. (*To the witness.*) You adopted a certain microscopical mode, taking as the basis the quantity of fœces apparent under the microscope, and the droppings from the horses in the street?—Yes.

16,620. Did you make a series of investigations to determine what was the percentage of those substances to be found all the way down the river?—Yes.

16,621. Will you give the results of what you ascertained?—This is a diagram illustrative of the mud in Erith (*exhibiting the same*). You will notice in the pure mud which you get in the Essex rivers you get none of these objects.

(*Chairman.*) We should prefer to have your results, and not your processes.

16,622. (*Mr. Michael.*) Will you tell us what are the results you obtained, beginning at Teddington and going down?—I applied this method which is described in the report, to the whole length of the river, and I found that the results varied according as I took into consideration the mud itself, or the amount of this material present in the water. If I took the mud itself, to my great surprise I found that the amount per cent. of the detritus of human fœces was much greater in the mud above the weir at Teddington than in any part of the river below. It will be seen that it is greatest at Teddington and gradually decreases. On the contrary, the amount per cent. of the washings of horse excrement decreases till you come towards London, that it runs up to its great maximum at London Bridge, then it runs down again, and again runs up to a small maximum off Barking Creek, and then decreases down to the sea, that is the quantity per cent. in the mud.

16,623. Now what is the quantity found in the water?—If you refer to the diagram No. 5, you find that the amount of detritus of human fœces in a given quantity of water, increases till you get to London Bridge, then it decreases, and again runs up to another maximum between Erith and Barking Creek, and then decreases to the sea.

16,624. (*Chairman.*) It decreases from London Bridge?—It decreases between London Bridge and lower down. Then with regard to the amount per gallon of the washings of horse excrement, it increases to a very large maximum at London Bridge, it drops sharply to Blackwall and then decreases regularly to Sheerness, so that if you take into consideration the quality of the mud alone, you find it really worse above London Bridge than below, but if you take into consideration the quantity per gallon of water, the maximum point is at London Bridge.

16,625. (*Mr. Michael.*) Have you made investigations also as to any destructive influence which was exercised upon the sewage matter by microscopic animals which you found in the water?—I may say

I was very much struck with the enormous number of the excrements of minute crustaceans, entomostraca mainly. I have carefully examined that question, and at page 13 I give the number of those excrements which can be counted in a given unit weight of the mud. At Hammersmith it is sometimes as much as 1,100 in the one-twentieth part of a grain, and the average number of such excrements in the surface water of the river is 166. But at Erith, taking into consideration the entire depth of the river, in August the average number in the one-twentieth part of a grain of the mud is 360, but in May it was only 240. I may say I found there was an inverse proportion between the amount of detritus of human fœces at Erith and the number of those excrements. I found that in summer when there was a large number of those excrements of minute crustaceans there was a much smaller quantity of the detritus of human fœces, but in winter when those animals live to a very small extent, the detritus of human fœces existed to a much larger amount. It would appear that in summer three-fourths of the detritus of human fœces are removed before they get to Erith, and the conclusion I came to from my observations was this, that these minute animals live upon the organic matter which is contained in the mud. As far as I could ascertain from the microscopic structure of their fœces, I have come to the conclusion that sometimes they have an imperfect digestion. I could see portions of the finely granulated matter into which human fœces decompose, but as I was not satisfied with the theory I was desirous of ascertaining the facts by actual experiment, so at Greenhithe six weeks ago I collected a number of these entomostraca and put in with them a small portion of human fœces, and directly it was in they attacked it; they evidently knew perfectly well what it was, you could see them at it. I have kept a number of them for six weeks, and you could see that they are healthy and happy and in good spirits; you could see them eating the human excrement all the time.

16,626. (*Chairman.*) What is the size of these things?—They are very small, but then they are very numerous. This (*showing a tube*) shows about 100, found in the quantity that I collected upon one occasion.

16,627. (*Mr. Michael.*) What are those?—Those are Cyclops, and these (*producing another tube*) are Daphne; they were twice as numerous at Erith as at Crossness.

16,628. You would say that they exist in such enormous quantity as to exercise a large influence in destroying the fœces contained in the water?—The enormous amount of them is so surprising that I almost hesitate to convey any idea of it. I find taking the whole depth of mud at Erith the total number of the excrements of these small crustaceans would be about 6,000 per grain of mud.

16,629. (*Prof. Williamson.*) And how many would there be of these little beasts?—That varies according to the condition of the tide, but the conclusion I have come to is this, that the maximum number at Erith in the summer, and later on in the year, would be about 25 per gallon, and that the amount of human excrement at the time present in the water for their food would be less than $\frac{6}{1000}$ths of a grain, and it must be recollected that this $\frac{6}{1000}$ths of a grain of human excrement would include parts which they could not possibly eat or digest, they would only feed upon certain portions; in fact, there would certainly not be more than $\frac{1}{200}$th of a grain per gallon as food for 25 of them. So I feel sure that these little creatures must, although they are small, play a very important part, and be in number fairly comparable to the material they have to deal with.

16,630. (*Mr. Michael.*) Have you also found that anellids, and other mud worms, perform a very important part in disposing of the animal matter that may be found in the mud?—I have no doubt whatever that the small worms which you find in the mud play a most important part in the destruction of the sewage.

16,631. How have you arrived at that conclusion?—I have not made any actual experiment, but they are very numerous. Mr. Charles Darwin has shown what a very important part the earth worms play in the production of vegetable earth, and in the same way these anellids perform the same function in the water as the earth worms do upon the land.

16,632. Have you collected samples of the mud?—I have collected the mud in a glass beaker, and have observed the worms wriggle through it in making their countless holes, and I have not the slightest doubt that their nutriment is the mud which, like the earth worms, they swallow and eject, utilizing the organic matter present. That is the only source of food which they could have, and I think that is the principal cause of difference between the character of the mud at the surface and a little way down. At the surface you find it contains a vast number of the excrements of small animals, but if you go a little way down you find they are all decomposed and gone, and that there is no trace of the characteristic components of sewage, and I take that as very much due to the action of these worms.

16,633. Do you find a difference with regard to the amount of suspended matter upon the surface, and at the bottom of the stream?—That depends upon the condition of the tide. My experiments were made at half-ebb and half-flood. In some cases the current runs so extremely strong at spring tide, that there is occasionally as much mud held in suspension at the surface as at the bottom; but as a general rule there is much more mud held in suspension near the bottom, and there is a different distribution of the constituents, as I have shown in my report.

16,634. Is there a great deal of difference in the action of these animals, in your experience, in the summer and in the winter time?—I think there can be no doubt about that, because the number of excrements in a given quantity of mud varies greatly, and varies in an inverse proportion to the amount of human fœces contained in the mud.

16,635. (*Chairman.*) Do you mean that you find the excrements of these creatures?—You can see them perfectly, but I did not like to make a drawing of them, because everybody would laugh. They are so exactly like what we are familiar with upon a very small scale.

16,636. (*Mr. Michael.*) You produce, I believe, a sample of the mud which you collected by means of a small strainer?—I do (*showing the same*). I may, perhaps, state the conclusion I came to, and which is given in one of my tables here. The plan I adopted was to collect the material at mid-stream, at half-ebb, and half-flood. I collected the material at the surface, half-way down, and at the bottom. I determined the amount of the material, and by the microscope I determined the percentage of sewage matter, and by multiplying the two together I obtained the amount of material that is derived from sewage. By staying on the spot for a month I was able to ascertain the laws of the variation of this material. I found the main factors were the tide and the rainfall, but that on the average the amount of the sewage material carried up by the flood tide was 40 per cent. of that carried down by the ebb tide, but that that varied according to the tide, and that at spring tides the amount of sewage material carried up was only 24 per cent. of that carried down. Those two bottles contain the amount of material that will not pass through a sieve with apertures of a two-hundredth of an inch in diameter. All the normal mud of the river passes through the meshes. You have here portions of straw and hairs, and other matters, and other not truly river particles, that will not pass through. (*The witness exhibited two sample bottles.*) One of those bottles shows the total amount of material more than $\frac{1}{200}$ of an inch in diameter contained in 50 gallons at half-ebb, and the other the same amount at half-flood, at spring tide.

*Mr. H. C. Sorby, LL.D., F.R.S.*

26 June 1883.

16,637. In order to make a determination, have you not also taken out, and will you explain to the Commission, the sand of the sewage and the sand occurring in the banks of the river under the various conditions you have dealt with?—The method I have employed now is pretty nearly the same as I employed in the Crossness Inquiry. That was founded upon the difference between the amount of flint sand and quartz sand, and in order to show how those can be distinguished I have prepared this diagram (*showing a coloured diagram*). In using polarised light and rotating the glass round, you get it either light or dark, as the case may be, and that shows quartz. Now flint, on the contrary, has a compound optical structure, and exhibits light at all times.

16,638. So that you are at all times able to determine between quartz sand and flint sand?—Yes.

16,639. And is that of importance in determining this question of the description of sand found in the banks?—I find in the road drift there is a very large amount of flint as compared to quartz. The sand of the sewage I found contained about 14 per cent. of flint. I counted a large number of the grains, so as to enable me to ascertain the ratio, but you will find that the normal sand of the river far below London, the old sand that was deposited to form the saltings, contains only 1 per cent. of the flint, and that enables you to determine approximately the amount of sand derivable from sewage, which is now contained in the mud deposited at Erith. That is the sand from the drift (*showing a sample*), and that is the sand from the sewage (*showing another sample*); that is the sand from Coalhouse Point (*showing a third sample*). I also exhibit samples of the sand from the saltings, and of the sand from the banks at Erith. (*The same were exhibited.*)

16,640. (*Chairman.*) Has the road drift been brought down by the sewage?—The sample you have before you is from the road drift found in the sewage.

16,641. (*Mr. Michael.*) Your object in showing these four specimens is this, is it not: You begin with the road drift, and then you come to the sewage; do you find the same kind of sand as is characteristic of road drift in the sewage?—Yes.

16,642. Then do you take as a specimen what is the natural condition of sand in the saltings?—Yes.

16,643. Then do you take the mud banks complained of at Erith, and do you find in the mud banks exactly the same sand as that which is found in the old saltings in the bed of the river?—Yes.

16,644. And considerably differing from the sand you find in the sewage?—Decidedly.

16,645. Now I will ask you as to the general conclusions at which you arrive?—May I beg to be allowed to make one remark first. By studying the quartz the conclusion I come to is that the amount of sand derived from the sewage at Erith is 3·24 per cent., that is to say, sand of sewage origin. By studying the mud by the other method, that is to say, by the hairs of the oats, the average percentage was 3·29; so that you have 3·24 by one method, and 3·29 by the other.

16,646. That is so close an agreement as to give you considerable confidence in the results you obtained?—Yes, but I may say that that refers not to the objectionable constituents of sewage, but to the mineral matter.

16,647. Have you found that the quantitative method you have employed may be relied upon?—I find it is far more accurate than is requisite for the purpose before us.

16,648. Has it enabled you to obtain an idea of the character of the contamination in various parts of the river as set out in this report?—Yes.

16,649. Have you arrived at the conclusion from the mode you have adopted that a large portion of the more objectionable ingredients of the sewage are removed, especially in summer, by the action of minute animals?—Yes.

16,650. And that there is a very large biological influence exercised?—Yes.

16,651. Your fourth conclusion is, that the combined effect of these, and of the large volume of the river near the outfall, is to rapidly reduce the percentage of sewage in the mud and in the water to considerably less than what it is above the outfalls?—I have here a diagram which shows the reduction in the amount of the detritus of human fœces and horse droppings from the streets; it shows an extremely rapid reduction in quantity, the one being due to dilution and the other to consumption by minute animals, and to decomposition.

16,652. Then you find, "That the unregulated "introduction of impurities from various sources "above the outfalls, where the volume of water is "relatively small, causes the river between London "Bridge and Blackwall to contain more impurity "per gallon of water than below the outfalls, where "there is a regulated discharge of a larger amount"?—The facts certainly show that.

16,653. Do you find, "That the greater amount of "impurity near London Bridge is not due to material "drifted up from the outfalls"?—You find the amount of impurity in the half ebb at London Bridge and at low water is very much greater than at half flood and at high water. Other facts show that that method can be relied upon.

16,654. (*Chairman.*) The other thing is that it diminishes between London Bridge and the outfalls? The detritus of human fœces does not materially decrease, but the road drift decreases very rapidly.

16,655. What strikes me is, how that can possibly be so?—I think it can be explained by the increased volume of water. There is a diagram here which shows that if the river were of uniform magnitude there would be an enormous increase off Barking Creek and Crossness; but when you take into account the increased volume of water, it is accounted for. If the river had remained at even volume this line (*pointing to the diagram*) would be the result; but the lower line is what it actually is, being due to dilution.

16,656. (*Mr. Michael.*) You say you believe that the greater amount of impurity near London Bridge is not due to material drifted up from the outfalls?—I think so, because you find that the water which comes up is much more pure than that which comes down. I have paid very great attention to that point, and my observations all bear it out in the most conclusive manner, both when you study the water upon the surface and in the whole depth of the river.

16,657. Can you explain why the effect of the discharge is so small, except over a limited area?—I think it must be due to the enormous dilution and to the destruction by chemical and vital action.

16,658. You have stated that the mud deposited at Erith, instead of being sewage mud, differs only by 3·29 per cent. from the ordinary saltings mud which you would find in other parts of the river if there were no sewage?—That is so.

16,659. Is it true that the results you have given apply to dry weather?—My experiments were carried out when there was hardly any rainfall, and I afterwards also examined samples collected at a time when there was a large rainfall, and I found the reduction of impurity was very great indeed. I found that off Woolwich and Barking Creek the reduction was to about one-third.

16,660. More than one half?—Yes.

16,661. And all those things have been the result of personal experiment upon the river for three months, and before that time?—Yes.

16,662. (*Chairman.*) What is the mud upon the banks of the river composed of, say at Erith; you say that sand (*exhibiting one of the sample bottles*) is a part of it?—Yes.

16,663. That can only be held in suspension, I suppose, if you put it in water; it will not be in solution, I suppose?—No, in suspension.

16,664. What are the other constituents of the mud?—The ordinary constituents of clay and shale

deposits; the material produced by the decomposition of feltspar and other material, associated with organic and other matter, and of course there are a number of other things, such as diatoms, and so on, contained in it.

16,665. I think you say that there is about one per cent. of sewage matter in the mud?—The mud at Erith in the summer now contains upon the average about 4 per cent. of the indestructible material of sewage, but three-fourths of the readily decomposed material has been decomposed before it gets to Erith.

16,666. But I am speaking of the mud at Erith; what is that composed of?—Four per cent. of the indestructible part of ordinary sewage and one per cent. of the destructible.

16,667. The indestructible being innocuous?—Yes.

16,668. That does not include the hairs of oats, does it?—Yes, it does.

16,669. That is indestructible?—You can detect them as far as Yantlet Creek; they are not dissolved by nitric acid, so I look upon them as comparatively indestructible.

16,670. What is the other one per cent.?—As far as my investigations go, the mud which is carried down the river contains in summer about one per cent. of detritus from human fœces.

16,671. When you say "detritus," it has not been altered, not oxidised, or anything of the kind?—No, it is in the normal condition.

16,672. Only granulated or disintegrated?—Yes, quite so, and some are larger fragments.

16,673. Why would not that smell if it were exposed to the air?—You perceive the amount is very small. That is not the amount that is deposited; there is not so much as that deposited upon the side of the river.

16,674. But I am talking of the mud itself?—The mud deposited upon the shore contains considerably less than that; it contains from one third of a pound to half a pound per ton.

16,675. That would be about one forty-fifth per cent. or less, and that would not smell, you think?—That I am not prepared to say. I could not smell it; that is all I know. I lived at Erith six weeks, and I can say that the only nuisance we experienced there, was the coal dust from Messrs. Beadle Brothers' coal wharf.

*Mr. H. C. Sorby, LL.D., F.R.S.*

26 June 1883.

16,676. But you have been upon the shore of course?—Yes, I have.

16,677. Upon the mud?—I have not been very much upon the mud, because I am upon the river almost all the time, and I do not go upon the mud except when I go to collect material, but we never detected anything that was objectionable.

16,678. You do not know that it did not smell?—We did not smell it, at all events.

16,679. But you were not upon the mud?—We were upon the mud collecting materials. My men all laughed at the smell of the river, but they do complain of the smell of the factories.

16,680. (*Sir John Coode.*) Where you said 1 per cent. of detritus (I think you said 1 per cent.), you did not mean detritus in the sense of deposit from the road washings, but you meant 1 per cent. of solids in the sewage?—I meant 1 per cent. of the detritus of human fœces, the insoluble portions, and 4 per cent. of the material that is of an indestructible character.

16,681. (*Prof. Williamson.*) You mentioned the circumstance that you found a considerable quantity of the excrement of these small animals, the entomostraca, and that you ascribed that to the transformation of the human fœces which they had consumed, so that those represented a smaller quantity than the substance they eat; now does this excrement represent organic matter which might become offensive?—I am unable to say that; one knows necessarily that if they live upon the material they must consume a considerable portion of it, and that their excrements do not contain the whole of what they eat. No doubt they must digest some portion of what they eat, but they do not completely digest it all, and their excrements might possibly be the source in large quantities of disagreeable results.

*Mr. Beaumont Morice* applied for leave to postpone his cross-examination, upon the ground of the amount of evidence put in by the witness in the form of a report.

Adjourned to to-morrow at half-past 12 o'clock.

# FORTY-FOURTH DAY.

## Wednesday, 27th June 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S. IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
WILLIAM POLE, Esq., F.R.S., *Secretary.*

(*Mr. Webster.*) My Lord, as the evidence is drawing to a close, might I mention one matter upon which I would ask for information. Mr. Law suggested on the 26th May that, though there had been a continuous rainfall, there had been no overflow. I put it to him upon instructions that upon that day which he mentioned, the 26th May, the Blackfriars sewer had run strong with sewage during the whole day; and your Lordship was good enough to say that I was perfectly right in pointing that out to him, and requested that inquiries might be made to ascertain whether that was the fact. I would ask my learned friend, Mr. Norman Bazalgette, whether he is able to state that as a fact; if not, I must get the pierman at Blackfriars to attend here to prove it.

(*Mr. Norman Bazalgette.*) Mr. Law is not here, but I will send for him.

27 June 1883.

(*Mr. Webster.*) I merely do not wish it to be lost sight of.

(*Chairman.*) Was that the day upon which he took the samples?

(*Mr. Webster.*) It was the day upon which he spoke of a quantity of rain having fallen to the extent of one-third of an inch in 9½ hours; and that, although they had only two sewers out of three at work, no overflow, as he stated, occurred at any part of the system. I have information from the pier-master at Blackfriars that there was an overflow during the greater part of the day.

(*Chairman.*) I really cannot see the relevancy of it

27 June 1883.

to this inquiry. What we really are engaged in inquiring about now, and I think I speak with the approbation of my brother Commissioners, is as to the condition of the river from Greenwich to below Greenhithe.

(*Mr. Webster.*) I am quite prepared for that; but I submit that if it be taken as the datum upon which the condition of the river below is to be ascertained; that upon a particular day when there was a great pressure of rain there was no overflow; and if Mr. Law has argued upon that basis,——

(*Chairman.*) Would you allow me. The quantity of sewage discharge is known; it is agreed; the discharging capacity of the sewers is known. If upon this particular day, in spite of these two known things which show that the Blackfriars sewer ought not to have discharged, it still did discharge, that indicates that there was something wrong or irregular with respect to this particular sewer.

(*Mr. Webster.*) Your Lordship does not quite follow me. I am not the least anxious to enter into an argument upon it; but if my learned friend, Mr. Bidder, should afterwards refer to this discharging capacity—

(*Chairman.*) If Mr. Bidder should say so, I, as at present advised, should make the same remark to him as I now make to you.

(*Sir John Coode.*) But Mr. Law is not here.

(*Chairman.*) Though I do not, if I may say so, care for Mr. Law, I care for what he proves.

(*Mr. Michael.*) I will send for Sir Joseph Bazalgette, and he shall give the information. I will undertake that it shall be given.

Mr. Henry Clifton Sorby, LL.D., F.R.S, called again; cross-examined by Mr. Webster.

*Mr. H. C. Sorby, LL.D., F.R.S.*

16,682. With regard to this very learned book which you have written, I will tell you at once I have not mastered a quarter of it, and therefore I will only ask you a few questions in cross-examination. In the first place, will you tell me what you include under the head of algæ?—There are a vast number of divisions of algæ but those to which I have specially referred are the confervoid algæ, the desmid algæ, and the diatoms.

16,683. Are those three classes sufficient in the percentage of the algæ to base your calculations upon?—Are you referring to the tables that I give at page 13?

16,684. I am referring to the blue line of algæ which appears upon diagram No. 1. In order that I may follow you, I should be glad if you would give me the generic names of the classes of algæ that you have taken?—I have united together the confervoid algæ and the desmid algæ and the diatoms.

16,685. And those may be taken to be what you have included under the name of "algæ"?—That blue line refers only to the relative amount.

16,686. But, in determining the relative amount, it refers to these three things that you have added together?—It does.

16,687. I have examined your tables to a certain extent. Am I right in saying that, except in certain cases, the proportion of road detritus to fæcal matter is about 4 to 1?—It varies in different parts. I allude to it in one particular case at one particular part of the year. I took it at Erith, but it varies at particular times of the year and according to circumstances.

16,688. Take page 17, where you say, "Taking "then as our standard for reference 100 muscle fragments and 100 oat hairs and spirals, we have as "follows for this mud at Erith: 1·08 per cent. of "the detritus of fæces in sewage and 4·11 per cent. "of the road drift." That is approximately 4 to 1?—That applies to the month when I was at Erith, and nothing more.

16,689. What I want o know is this,—Given any sample of water in which there is polluting matter, have you been able to determine what is the proportion of pollution due to road detritus as distinguished from sewage matter?—I think so.

16,690. What do you say is the general proportion?—In some cases there is a considerably larger proportion of detritus of human fæces to road drift; in other cases there is no trace whatever of detritus of fœces, and nothing but road drift. It is simply a question of time and of circumstances.

16,691. I have not made my question clear. In the sewage as discharged at the outfall, what do you take as the proportion of road detritus to sewage?—The calculations you are referring to refer to four per cent. and one per cent. of the amount which is present in the average sewage.

16,692. I may take it, may I not, that taking that to be something which represents approximately sewage mud, it would be 4 to 1?—At Erith at that time; at other parts of the river it differs enormously.

16,693. But I am taking Erith as representing something which is near the outfall. Now to pass to another matter (and I will take you as nearly as I can in the order of your pages). I will call your attention to page 5. The whole value of your theory depends upon the value of your quantitative process, does it not?—I will not say the whole, but to a large extent.

16,694. I do not say entirely, but do you substantially depend upon that?—I am willing to put it upon that basis.

16,695. Now I will call your attention to a statement made at the bottom of page 5. You say, speaking of certain things, "They often show the "microscopical structure of muscle to such marvellous perfection that they could not be confounded "with any other objects. Many of the fragments, "however, have no such form or structure as to "*completely prove* that they are derived from muscle, "though there can be no reasonable doubt. In "estimating the number in an unit volume of "material, *all* the former are counted, but *only half* "the latter. In other words *double value* is accorded "to those cases about which there can be no sort of "doubt." I want to understand how you got at this theory of counting only one half?—I thought it was the most accurate and the fairest way of dealing with the subject. Supposing you are studying this material derived from human fæces, there are a certain number about which you cannot doubt for a moment. About others there is no reasonable doubt, but there is no absolute proof. To leave those out altogether would be wrong, and to take them in altogether would be wrong; so I thought the fairest system would be to give half value to those. The same system has been carried out through the whole of my researches; so I think it is upon the whole the fairest and the most accurate way of dealing with it.

16,696. Now I will ask you this,—If you had followed the same system throughout, as you are only dealing with relative proportions, the relative proportions would probably have been the same?—I have no doubt about it.

16,697. Except what you have told us, have you any ground for taking the one-half?—I have no special reason, except that, if you were to take the whole, you would certainly be wrong, and if you had taken none you would also certainly be wrong.

16,698. So you thought that the fairest mode was to take half?—Yes; but, if you take one-third and apply it uniformly throughout the observations, you will get a very fair result.

16,699. It is upon the principle of getting the fairest approximation that you roughly can?—It is. As I have said, this method is to a large extent novel, and one must do the best one can; and I think I have adopted the best and, upon the whole, the fairest and most satisfactory way.

16,700. When you speak of its being "novel," a similar system has been used for counting the corpuscles in blood, has it not?—Yes, a similar principle.

16,701. Now, how do you get your figures for these minute things upon page 13?—When one has done the same operation a great many times, he is pretty well versed in it. The method I have adopted is, that I have the mud in a small test tube, with about two to three times its volume of water. Then I have a pipette of a different kind to what is usually employed. It is a glass tube open throughout, and of even diameter throughout, and with a small india-rubber ball at the top. The mud settles at the bottom, and the most important thing is to take out a certain portion of a perfectly uniform character. Then I put the pipette into the water, and take up a small portion. By this method I scarcely ever fail to get a proper amount upon the glass, and I get a perfectly uniform spread of material. If I get too much, I give the thin glass cover a slight squeeze and press a little out. Six observations of that sort are made, and if in one case I find I have taken too small a quantity, I take another dip and get a little more the next time, so that, upon the whole, I get a fair sample.

16,702. But how do you get at the $\frac{1}{20}$th of a grain?—I find that, by taking a considerable number of specimens of that kind, and washing the material off and weighing it. The quantity that I have adopted for the unit of observation weighs the $\frac{1}{20}$th of a grain.

16,703. It depends upon the accuracy of your taking up your given quantity each time?—No doubt it depends upon the skill of the operator.

16,704. The quantity you take up is divided into a number of fields, and then examined under the microscope; is that so?—No. You sweep over the whole. If that (*indicating a small surface*) were the entire surface of the glass, I have a mechanical stage, and I sweep up and down, so that I can look over the whole without missing any part of it.

16,705. Your quantity would depend upon the thickness of the field you were examining, would it not?—You can judge from the spread of the material. It depends partly upon the thickness and partly upon the closeness of the material; but by the large practice I have had, I think the results show that this method can be carried out with an abundant accuracy for the purpose of this inquiry.

16,706. You will agree with me, that I have not put it incorrectly, upon the instructions given to me, that the accuracy of this quantitative analysis would depend upon the closeness of the particles and the thickness of the field?—Yes, no doubt.

16,707. Would not a grain of sand separate the two glass surfaces so far as quite to upset the thickness of the field?—All the large grains are carefully washed away as I have described, because the large grains of sand would undoubtedly interfere with accuracy of observation.

16,708. All your experiments depends upon the fact that the grains of sand are carefully washed away?—Very often I find that the grains of sand have escaped, and in that case I should put the experiments aside; or if it were any other small object I should press the surface down I may confess that the success of the method does depend upon the skill of the operator. If you were to give anyone totally inexperienced with the method that observation to make, he would make, in nine times out of ten, a mistake. I used to make a great many blunders, but by practice I have been able to do it in a manner which, I may say, now astonishes myself.

16,709. Now will you look at page 7, where you give the ultimate per-centage at 13. Do you use that per-centage afterwards in your tables?—No, it is not used at all; it is merely to show that you may express the character of the road drift in these terms; it is not used at all afterwards.

16,710. I want to get clearly from you that you do not use in the tables the per-centage thereby arrived at?—No; that is only to show that the relative number of spiral vessels and hairs of oats, upon the average, corresponds with that in the excrement of horses; it is only showing the relation between the road drift and the excrement of horses.

16,711. Because I call attention to the fact that it would be scarcely a correct method of arriving at the average, to add these numbers up and divide them?—Yes, it would; because I show that in the excrement of horses there are 13 per cent. of the spiral vessels and hairs of oats, and it is the same in the road drift.

16,712. Now what year does "Barking, May 4th and 26th," upon page 9, refer to?—The whole of that table relates to 1882.

16,713. All that table?—All the specimens described in this Report were specimens collected last year.

16,714. You mean 1882?—Yes, all those specimens were supplied to me by Mr. Dibdin for the Metropolitan Board of Works. I had nothing to do with the collecting of those specimens.

16,715. It is suggested to me that that cannot be so with regard to the specimens collected in March?—It is so, because I examined them in March, and I can guarantee they were not collected afterwards.

16,716. Will you turn, if you please, to diagram No. 5, showing the relative amounts of detritus of fæces, and of the residue of horse excrements in equal quantities of water; the red line is the fæces, and the blue line the horse excrement?—Yes.

16,717. According to this diagram, if I rightly understand it, there is more of fæces and excrement at London Bridge than there is at Barking, and just below the outfall at Erith?—Yes, per gallon of water.

16,718. Is there more in the sewage itself? I do not understand it; do you say the sewage which is turned out at Barking has more or less in it per gallon than the water into which it is turned?—A very great deal more; that is shown in another diagram. That diagram refers to the mid-stream, and not to the sewage flow.

16,719. Will you just explain to me. Is this diagram to show that the water at London Bridge is worse than the water at Barking Creek, when the sewage is turned into it, or not?—I think so, decidedly, per gallon.

16,720. If it is per gallon it is per river, I should have thought.

(*Chairman.*) No, because there are more gallons at Erith.

(*Mr. Webster.*) Suppose there are 10,000 gallons at London Bridge, and 10,000,000 gallons at Erith, if it is worse per gallon I should be justified in thinking that it is worse per river.

(*Chairman.*) No, I do not think so. Suppose there are half a dozen persons with two sixpences upon them, and there are two persons with six sixpences upon them, which of them has got the most sixpences upon them?

16,721. (*Mr. Webster to the witness.*) Gallon per gallon, you say the river is worse at London Bridge than it is at Erith?—I do say so. The very first day I devoted to this subject I came to that conclusion, and the more I worked at it the more the facts justified me in thinking so.

16,722. That, you think, is the result which the diagram shows?—That applies more especially to the residue of road detritus, and that, no doubt, is to a large extent due to the fact that this is material that does not decompose, and that has been gradually increasing down the river, while the river has not increased in magnitude in proportion.

16,723. That table is based, is it not, upon the accuracy of this quantitative system?—Quite so.

16,724. Will you kindly turn, if you please, to page 6 for a moment. I want to get this clearly from you. On page 6 you refer to the effect of spirals as being developed from green vegetable food, and the other matters you referred to; have you read Dr. Tidy's evidence upon that head?—Yes, I have.

16,725. I think you say you agree with him as to

*Mr. H. C. Sorby, LL.D., F.R.S.*

27 June 1883.

what spirals show, do you not?—Yes; only you have a large number of spiral vessels in the road drift which have come from the excrements of horses.

16,726. Then you say on page 12, "Another most "important constituent of the mud all down the "river is the excrements of minute crustaceans and "other small animals. The nature of these admits of "no sort of doubt, since they can be seen *inside* the "small transparent creatures, and are rapidly voided "when the minute shrimps, which occasionally occur "in such vast numbers in the lower part of the river, "are kept for a short time in water. In the upper "part of the river, where the water is fresh, the "common forms are Cyclops, Cypris, and Daphne. "Having kept tame shrimps for months which fed "out of my hand, I have no sort of doubt as to their "carnivorous habits, and do not hesitate to conclude "that the whole class feeds on the muscle fragments "suspended in the river water, and on the finer "grained mud containing much organic matter." Do not you know that a large number of these same animals, or whatever you call them, have been found to abound in water in which there is neither muscle nor sewage matter?—That is quite probable; they occur in great numbers in the sea.

16,727. And not only there, but in river streams in which there is neither sewage matter nor muscle?—That is so.

16,728. I do not know how you can base any argument to the effect that these are principally carnivorous animals which feed upon muscle fragments?—Crustaceans are most voracious; they will eat almost anything that can be looked upon as of animal nature; they eat one another, and they eat anything they can get.

16,729. If they only eat one another, they would come to an end very quickly?—They will eat any dead one as soon as they can get him.

16,730. If it be the fact that these animals are found in as large proportion in streams which have not got muscle in them, and have not got sewage matter in them, is your deduction quite sound?

16,731. (*Chairman.*) Did you say that? Is it the case that they are found in rivers where there is no sewage matter in as large a proportion as in sewage rivers?—I am not prepared to say that, because I am not aware that anyone has hitherto adopted the quantitative method with respect to them. As far as I have been able to examine at other times of the year, the circumstances being the same, there are not the same quantity in the pure water as in the impure.

16,732. (*Mr. Webster.*) What you say here is that you "have no doubt as to their carnivorous habits, "and do not hesitate to conclude that the whole class "feeds on the muscle fragments suspended in the "river water"?—I do not mean to say that they do not eat anything else, but that they do eat the muscular fragments suspended in the river water. As soon as I got to Greenhithe I collected a number of those Cyclops, and I thought it was very important to ascertain whether they would eat this material; and having got some of them in a glass beaker, I added some portions of human excrement and they immediately attacked it. I have kept them alive for six weeks, and there they are as healthy and hearty as they were to begin with, and they have nothing else to eat.

16,733. But I should think there was very good vegetable matter in human excrement to eat; I do not see why it follows that they eat only muscle?—But there is no evidence that crustaceans eat vegetable matter.

16,734. (*Dr. de Chaumont.*) Is it not the fact that entomostraca are present in considerable quantity in well water?—I think it is quite possible, and in that case my impression is that they would feed on any polygastric animalculæ they could get hold of. All I contend is, that these entomostraca must eat a large quantity of this material; they will eat it, as I know. The number of their excrements down the river is enormous, and that must be accounted for by something they have eaten.

16,735. (*Sir John Coode.*) Would you consider the excrements of the entomostraca are innocuous?—That I am not prepared to say.

16,736. I ask the question because it might be only a change of size in the excreta?—With this qualification, an animal eats a certain amount of food; the amount of the excrement is not equal to the amount of food consumed. For instance, we eat a large quantity of food, but nobody imagines for a moment that the whole of that passes out in our excrement. A certain portion does pass out, but by the life process a large amount is absolutely consumed and oxidized; the rest passes in the excrement.

16,737. (*Mr. Webster.*) A member of the Commission has put questions upon that point which render any further examination by me upon it unnecessary. Now I will call attention to Table 5, page 13. "Barking Creek means 21,000 algæ; sewage flow "after 1½ miles, August 11th, 22,000." Is that 1½ miles below Barking?—Yes, a number of specimens were collected at half a mile, a mile, and a mile and a half.

16,738. But does the 1½ miles mean below Barking?—Yes, in the line of the sewage flow.

16,739. Did you take it below Crossness as well?—No, those specimens were not collected for this special purpose but for another purpose.

16,740. Where do the algæ come from, out of the sewage?—Certainly not; there are very few in the sewage.

16,741. This is per $\frac{1}{20}$th of a grain per unit?—Yes.

16,742. To what do you attribute the enormous increase of algæ at Barking as distinguished from Woolwich, and in the 1½ miles as distinguished from Woolwich?—Diagram No. 1 will show that.

16,743. If this quantitative analysis is reliable, and you say they did not come out of the sewage, where can they have come from to have increased in this extraordinary manner between Woolwich and Barking?—It is an enormously rapid growth. Those that are met with at London Bridge are small, and as you get down the river you find them greatly increase in size and in number. I was, myself, astonished at the facts, but I cannot doubt the facts for a moment, because they are so patent.

16,744. But this is number and not size?

(*Chairman.*) Would you allow me to suggest that the difference amounts to 5 per cent.?

(*Mr. Webster.*) Not between the 9,000 and the 22,000. I am taking it as between Woolwich and Barking first.

(*Witness.*) It may partly be due to the fact that they are a species which live best in brackish water.

(*Chairman.*) It may be that they find more food.

(*Witness.*) I think it may be partly due to the fact that those are algæ and diatoms, which live better in brackish water. They are of a kind which do not occur higher up the river except in small quantity, and this species that are met with at London Bridge are small; they appear not to be growing in favourable conditions. At the outfalls they increase in size and in number, and when you get further down still, they get into too salt water conditions to enable them to develop. My impression is, that the carbonic acid in the river water near the outfalls enables them to grow more rapidly than they can do in pure water; if there were no carbonic acid they would not grow at all.

16,745. (*Mr. Webster.*) But where does the carbonic acid come from that is down there?—If you have sewage thrown into the river, and oxidation takes place, the carbonic acid must be produced.

16,746. You say the oxidation of the sewage frees the carbonic acid, and that enables these creatures to multiply and grow?—It must. I take it that the greater number is the test of the fact and of the partial saltness of the water.

16,747. I want to call attention to page 18 of your report with regard to the term "Sewage flow 1½ miles below outfall"; is that below Barking?—Yes.

16,748. Has it not been observed below Crossness?

—No; these were collected for a particular purpose apart from this.

16,749. Nowhere in your tables do you seem to have regarded the Crossness outfall; is that a mere accident?—The Crossness outfall has been studied quite as much as the Barking outfall.

16,750. But I do not find that any of these tables, either No. 5 or No. 6 or No. 7, deals with the sewage below Crossness anywhere?—We collected that sewage at Barking because the Barking sewage is stronger; it is a richer and a stronger sewage than at Crossness.

16,751. You mean the sewage which comes out of the northern outfall?—Yes; we thought it best to take the very worst we could get, but Crossness has not been omitted at all.

16,752. Now I will take page 19, "Teddington above weir." I want to call your attention to a remarkable fact that Teddington above weir is shown to contain 32·0 of oat hairs and 28·0 muscle fibres. Where were those taken?—I do not know; they were not collected by myself. I am informed they were collected in mid-stream immediately above the weir.

16,753. Immediately below the weir it sinks to 10 of muscle fibres directly?—Because it is diluted with a larger amount of mineral matter; there was a larger amount of mud per gallon, that mud being stirred up by the fall over the weir, I think.

16,754. Is the result of this Table 8 to show that the water at Teddington is worse than the water at Barking Creek?—The mud itself is worse, but the water itself is not.

16,755. This is suspended in the water, you know?—No; that is the amount in an equal weight of mud.

16,756. I will call your attention to the heading "Showing the number of muscle fibres, &c., &c., in "various samples of the mud suspended near the "surface in mid-stream"; that is the mud floating in the water or stirred up in the water?—Yes, and those are per-centages by weight of the mud not of the water. If you will refer to Table 13 you will see the whole thing plainly; you will see that the total amount per gallon of water is very small. I must confess I was exceedingly astonished to find that amount of human fæces in the water at that part, but I had only one specimen for examination.

16,757. What I put to you is this: do you think that was an examination upon which you could rely for the water above Teddington Weir, when you found such a result as you did on the 28th of August, that is to say, contrasting Teddington with Barking?—The reason such a few specimens were collected there was that it was not thought necessary for the purpose of the inquiry, and it was too late to collect others when the importance of it was known.

16,758. Do you think that could be relied upon?—I think sometimes it might be twice as bad and sometimes not so bad.

16,759. If you will observe the oat hairs they do not seem to corroborate you at all?—There is no definite connexion between the two.

16,760. But when I asked you how it fell so much immediately below the weir, you said that was due to so much more mud being stirred up by the water tumbling over the weir. If that were so, that would apply as much to the oat hairs as to the muscle fibres, would it not?—I quite admit that to some extent; but, considering there were only two specimens taken, such a thing might easily happen. And, again, you must bear in mind that there is a possibility that a certain portion of muscle fibre might be destroyed; the muscle fibre is a materal which would be much more readily destroyed than the oat hairs.

16,761. We will look at the general conclusion in a minute or two. I will first call your attention to page 30, where you say, "This amount of material "brought back varies much according to the state of "the tide. Dividing my observations into two periods, "one of slack and the other of strong tide, we have "as follows: from August 12th to 16th and 22nd to "28th inclusive, being periods of weak tides, 66 per "cent. brought back; and from August 17th to 21st "and 29th to September 3rd, being periods of strong "tides, 24 per cent. brought back." Is it not the fact that during both those earlier periods the tides were making, and that during both the latter periods the tides were taking off?—No; those are divided into periods equally on each side of the minimum tide and the maximum tide, as far as I could it.

16,762. We can get it from a tide table?—The whole of the data during that period are given on page 29.

16,763. Do you know the difference between the spring tides making up and taking off?—I certainly do, seeing that I live on the water five months in the year.

16,764. I am told that the first two periods, when the larger quantity is brought back, are periods when the flood tides were making; that is to say, the flood tides were getting stronger every tide, and that in the other two periods the flood tides were taking off—going down to the neap?—I do not fairly understand you. They are taken at even times. From August 12th to the 16th you will find that is the period of the weak tide.

16,765. They were making then?—Yes.

16,766. And then in the second period, from the 22nd to the 28th, they were making, were they not?—No. On the 22nd 14·6 was the range, and it came on the 24th to 13·7.

(*Sir John Coode.*) From the 13th to the 22nd of August they were falling, and from the 22nd to the 28th they were rising.

16,767. (*Mr. Webster.*) It follows from that, that the balance in both those cases is in favour of taking off, as they were making two days and taking off four days. Now, upon the last of the two periods, from August 17th to the 21st, and from the 29th August to the 3rd September, were they making?—They were the periods of strong tide.

16,768–78. Were not they taking off at that time?—They were partly taking off; they were first increasing and then taking off.

(*Sir John Coode.*) It is quite clear from the table.

(*Witness.*) This diagram, No. 10, shows it perfectly well; that shows the range of the tide, and you find the maximum point exactly corresponds with the maximum range of the tide; the secondary maximum is due to the rainfall which is marked upon the table.

16,779. (*Mr. Webster.*) Now I want to call your attention to the results shown upon your tables on pages 28 and 29, taking especially the observations of the 21st of August. I call your attention to the table upon page 29, when there was an impulse or extra quantity of 601,000,000 gallons?—Those results are not from my own observations.

16,780. But, assuming them to be accurate, and you have put them in, it is the fact, is it not, that contemporaneously with the increase of water upon the 21st, there was an increase of solid matter in the sewage at Erith? I call your attention to your own deduction upon page 28, where you say, "The "maximum of residue carried down on September 2nd "is a day later than the maximum tide, and appears "to have been caused by the extra rainfall on "September 1st?"—Yes.

16,781. The deduction you draw is that the effect of the impulse of the increased upland water is to increase the quantity of solid matter which appears in the sewage?—It is the solid matter carried down the river.

16,782. Then I will say the solid matter at Erith in 24 hours?—All I can say is this, that there is a rainfall taking place there. You will find that at that time there is a considerable rainfall at Erith, and the rain falling upon the mud banks washes the mud into the river.

16,783. Now I will call your attention to this: the secondary maximum on August 24th clearly corresponds with the well marked maximum of upland water upon that day.

(*Chairman.*) I thought the best thing I could do to

*Mr. H. C. Sorby, LL.D., F.R.S.*

27 June 1883.

get at an opinion upon this matter was to look at the general conclusions.

(*To Mr. Webster.*) Do you dispute them?

(*Mr. Webster.*) I do.

(*Chairman.*) Do you dispute the large quantity of the more objectionable constituents removed by minute animals?

(*Mr. Webster.*) Yes.

(*Chairman.*) Do you deny that the minute animals destroy any portion of the sewage?

(*Mr. Webster.*) Not as to "any portion."

(*Chairman.*) Do you deny that a large part is so destroyed?

16,784. (*Mr. Webster.*) I am instructed to ask a question as to that conclusion not being supported by scientific facts. (*To the witness.*) I will ask you to complete your answer?—It is merely that the extra amount of rain that was gauged at Seething Wells does not mean that; it was merely a guide to the amount of rain that was falling in other parts.

16,785. Now I will go to what Lord Bramwell referred to just now, that is, the conclusion stated at the end of the report. In the first conclusion I see you say in effect that the value of the quantitative method depends upon the accuracy of the observer?—It does so; only I would premise, that carried out in the way I have carried it out, it is proved to be accurate by the results I have obtained.

16,786. Now, you say that "a large part of the "more objectionable constituents of sewage are re- "moved in summer by the unobjectionable action of "minute animals." Now, I want you to tell me, as shortly as you can, with the facts you have before you, upon what you base that deduction?—Of course you cannot watch them eating it; it is a matter of inference. But what I contend is this, that when we find, in the winter time, a very few of these excrements as described in this report, compared to what we do in the summer, and at the time when there are very few of those excrements, you find that there is a large amount of debritus of human fæces, that is to say, comparatively large; and when you bear in mind the enormous number of these excrements, especially down the river, and that these excrements represent material which has been consumed; what I contend, I say, is that the large amount of these excrements, and the considerable number of these animals present in the river (which I have proved do feed upon these things), is proof that a large portion of the objectionable constituents of the sewage is so removed.

(*Chairman.*) I suppose the quantity of objectionable matter found in the water and in the mud is ascertainable by analysis and by examination. If a quantity of the sewage is gone it is gone by some means or another; by what means is perfectly immaterial; and this witness comes and corroborates the notion by saying there is something which takes away such and such portions of it.

(*Mr. Webster.*) I quite appreciate the crisp way in which your Lordship puts it; but I object to Dr. Sorby's conclusion, that it is removed in summer by minute animals, and not by being taken out to sea.

(*Chairman.*) But, supposing he is wrong, and that it is taken out to sea, what then; the question is, whether it is gone.

(*Mr. Webster.*) If it is a question of the tide taking it out, one would inquire why the algæ have not disappeared also.

(*Chairman.*) The witness gives *à priori* evidence to show that it would be gone, but the direct evidence is that it is gone.

(*Mr. Michael.*) And, besides, Dr. Sorby does not say that other means are not in operation.

(*Witness.*) As far as the tides are concerned, I have shown in my own tables that 60 per cent. of it is carried away.

(*Chairman to Mr. Webster.*) You cannot fail to have seen what has happened. We leave this room; the evidence given by the witnesses is handed to half a dozen people to pick all the holes that can be picked in it, and they come and instruct you upon it; what can you do except act upon those instructions.

(*Mr. Webster.*) I am perfectly incompetent myself to act in the matter without instructions.

(*Chairman.*) I can quite understand that, but I put it to you that it is immaterial.

16,787, (*Mr. Webster.*) If your Lordship thinks that it is immaterial, I will use my own judgment upon it, and not pursue it further. (*To the witness*). I will only put this one more question to you. Would you kindly tell me whether you have any fact upon which you base your deduction that a large part, I say distinctly "a large part," of the more objectionable constituents are removed in the summer by the unobjectionable action of minute animals?—What I put forward is, that the chemical gentlemen who have given evidence have altogether overlooked this large action; and when we find this enormous amount of excrement which undoubtedly comes from entomostraca, or something of the kind, which do eat these substances, and when you find 6,000 of them in a grain at Erith, that shows the immense number there must be of them, and the work they must do. Of course they are small. When you come to have 6,000 in a grain, you cannot expect them to be very large. A number of the statements made in this report have been substantiated by the experiments I have made lately. I have been following out quantitatively this analysis, showing how many of these things there are per gallon; and we know they rapidly increase, because it is stated that one of these cyclops can in a year, if they all survive, give rise to 4,000,000,000.

17,788. (*Chairman.*) Do you mean one of them does?—I do not say it does; it could, provided they all lived; they will increase to that extent if the conditions are favourable and they have abundance of food. Now those are rapidly growing, and my friend, Dr. Murie, of the Linnean Society, who came to see me at Erith, said, "You will find the number of them much greater later on in the year."

Re-examined by Mr. Michael.

16,789. Would you kindly explain to the Commission the meaning, on page 17, of the 1·08 per cent. and of the 4·11 per cent.; does that mean the constitution of the sewage or of the mud at Erith?—Of the mud at Erith.

Examined by the Commission.

16,790. (*Chairman.*) Is that cyclops visible to the naked eye?—Yes, readily; they are about one-sixteenth of an inch in length, and some are larger considerably; at Crossness you have a greater number of the Daphnes, which are larger than the Cyclops.

16,791. Is that their fæces (*pointing to a diagram*)?—Yes; that is greatly magnified.

16,792. How is it ascertained that they multiply to anything like the extent you mention?—I am not responsible for that, that is merely asserted in a work on crustaceans; but you will see they carry two bags of ova; it is known how long it is from the hatching until they can breed, and then it is only a question of calculation as to how rapidly they breed.

16,793. Then you have seen them feeding, you say?—Yes.

16,794. With the naked eye?—I used a pocket lens.

16,795. (*Dr. de Chaumont.*) You have spoken of the number of these animals in the mud; what becomes of them?—I find the principal source of their death is their being drifted out to where the water is too salt for them; the numbers of deaths depend upon the spring tides; the spring tides bring up more salt

water than is good for them, and they die; but in the meantime, when there is not so much salt water brought up, they live.

16,796. Do the carapaces remain?—Yes; you find the remains of them in the mud, but no doubt they are largely carried down and washed away with the other material.

16,797. (*Sir John Coode.*) If you turn to diagram No. 5, you have told us already that you were struck with the large relative amount of the detritus of human fæces near London Bridge?—Quite so.

16,798. It was very striking; but have you formed any conclusion as to how that large quantity is found in that part of the river?—I think a good deal must come from the shipping; but the difficulty to a large extent disappears when we take into account the large volume of the river further down.

*Mr. H. C. Sorby, LL.D., F.R.S.*

27 June 1883.

16,799. (*Chairman.*) Sir John Coode suggests to me that these creatures devour excrement, but that they leave their own excreta, and that their own excreta may be as noisome as what they devour?—I think it exceedingly probable that their excrement might be objectionable; but at the same time in the life process of the animals a very much larger amount of material would have been consumed than is given off in the excrement.

The witness withdrew.

(*Mr. Michael.*) There are two matters which we promised to put in, namely, extract from Dr. Collingridge affecting the West Ham pumping station at Bow Creek, and a return of the hand and steam dredging licenses from 1863 to 1882. (*The same were delivered in. See Appendices BS. and BT.*)

(*Mr. Beaumont Morice.*) Would you allow me to mention a matter, with regard to the evidence, which I brought forward in the early part of the Commission. Your Lordship knows that, on behalf of the memorialists, I brought forward a number of witnesses in November, when Sir Benson Maxwell was in the chair, and he intimated to me, on behalf of the Commission, that he thought it would be advisable not to call any more witnesses until my case had been seriously contested or attacked by the Metropolitan Board of Works. I have the passage, at page 43 of your Minutes, in which he stated, "I think that the "feeling of the Commission is that you, Mr. Morice, "have started a sufficient *primâ facie* case. If it "should be shown that your witnesses are really "mistaken, or that they are misleading us, we shall "give you the opportunity of calling any further "evidence that you may think necessary." I stated, in consequence of the statement by the Chairman, that I should not trouble the Commission at that time with any further evidence. That being so, I have only to say now, that having heard the evidence brought forward on behalf of the Metropolitan Board of Works, I have, and I beg to mention it to your Lordship, a number of witnesses, residents and others in Erith, whom I wish formally to tender on behalf of the memorialists and the Local Board of Erith, in order to show that the statements which have been made on behalf of the Metropolitan Board of Works have no foundation.

(*Chairman.*) I think Sir Peter Benson Maxwell's view was in conformity with one which I had mentioned.

(*Mr. Beaumont Morice.*) Yes, your Lordship did hint it previously.

(*Chairman.*) It has been familiar to counsel in cases of rights of way, and things of that description; that you have, say, 20 people, who will come and give you particular evidence, and it is quite possible that you would find 20 more who would come and do the same thing on the other side; that is to say, there would be 20 people who would give you a different character of evidence, showing that their passage had been interrupted, or that they had not exercised the right. What you may call the two twenties show the case upon either side as much as though you were to call two forties. To my mind, therefore, I cannot help thinking that it is no use duplicating the evidence.

(*Mr. Webster.*) My learned friend Mr. Beaumont Morice's point is, that there having been a general statement as to facts, there has been certain evidence given by the Board not upon the question of theory, but upon the question of fact; and if your Lordship thought that the evidence of the Erith witnesses was discredited at all by the evidence upon the question of fact, my learned friend would like to tender those further witnesses.

(*Chairman.*) The question of fact is the question of nuisance, and we have had the evidence of witnesses of undeniable and unimpeachable authority as to the subject of the nuisance. We have had the evidence of Captain Burstal as to the nuisance at Woolwich, that sometimes the smell was intolerable.

(*Mr. Beaumont Morice.*) I fully felt the force of your Lordship's suggestion with regard to the undesirability of calling a great many witnesses at the time to repeat what others had said; but upon the question of fact, with regard to the nuisance, it is a feeling which is so widespread, that it is a matter of some difficulty to limit the number of witnesses that one could bring before your Lordship.

(*Chairman.*) I suppose you could occupy another month at it.

(*Mr. Beaumont Morice.*) I could certainly bring forward a number of witnesses, including residents.

(*Chairman.*) The best way would be for us to keep this matter over after the case for the defence is concluded, and if we think it right that you should call other witnesses, we will let you know before we next meet.

(*Mr. Webster.*) May I beg to say that if your Lordship and the Commission will give us a fortnight it would be a great convenience. I cannot help your Lordship much in this matter, but I will help you as much as I can.

(*Chairman.*) I do not agree with that. I think the assistance of counsel will be of very great use to us.

Mr. Hugh Herbert Mason called; examined by Mr. Norman Bazalgette.

16,800. You live at East Street, Barking, and you are a member of the Royal College of Surgeons, and a licentiate of the Society of Apothecaries, and holder of Sanitary Science certificate, Cambridge?—Yes.

16,801. Have you, since the formation of the East Ham Local Board in 1877, occupied the position of Medical Officer of Health for East Ham?—Yes.

16,802. What does the district of East Ham include?—The parish of East Ham includes a portion of the town of North Woolwich, and a district extending back for about three miles.

16,803. (*Chairman.*) Does your district go to the river?—Yes, it goes to the river.

16,804. (*Mr. Norman Bazalgette.*) I think it includes that portion of North Woolwich which is not in the county of Kent?—Yes, it does.

*Mr. H. H. Mason.*

16,805. First of all, what do you say as to the health of the whole district, generally?—It is about the average of England.

16,806. Do you find any distinction between the health of that part which immediately adjoins the river and the rest of the district?—I find no distinction.

16,807. (*Chairman.*) Your district is above the outfall, is it not?—It is just above the outfall.

16,808. Is the outfall within it?—No, it is just outside.

16,809. (*Mr. Norman Bazalgette.*) Is your district

*Mr. H. H. Mason.*

27 June 1883.

specially subject to zymotic or other diseases, which might be attributed to emanations from the river?—No.

16,810. Where does your practice extend with regard to Barking Creek?—On both sides of it.

16,811. To its mouth?—Yes.

16,812. (*Chairman.*) Do you say you are upon both sides of Barking Creek?—Yes; my official district is only on the east side of Barking Creek, but I reside on the other side of it.

16,813. (*Mr. Norman Bazalgette.*) Your private practice is in a different area from your official practice?—Yes, it is.

16,814. At the mouth of the creek there are, I believe, 50 cottages, inhabited by the employés of Lawes' chemical works?—Yes, there are.

16,815. I believe those employés have a club, to which you are the doctor?—Yes, they have.

16,816. I presume those men are principally employed upon the banks of the river?—They are entirely.

16,817. What population do those cottages accommodate?—About 200 to 250.

16,818. What do you say as to their health?—It is about the average.

16,819. Do you find zymotic diseases have been more prevalent amongst them than in the rest of your neighbourhood?—No.

16,820. Have you met with any typhoid fever amongst them?—No, I have never seen typhoid fever there.

16,821. I believe in 1881 there was an epidemic of scarlet fever in East Ham?—Yes, there was.

16,822. Did that epidemic extend more beyond the district bordering upon the river than in other parts of the district?—No.

16,823. Have you met with any diphtheria at the cottages?—No.

16,824. Have you met with any illnesses which you could attribute generally to emanations from the river?—No.

16,825. Could they have occurred without your knowing of them?—No, they could not.

16,826. Just to localise Lawes' Chemical Works more nearly; they are exactly opposite the outfall, are they not?—They are about 300 yards below.

16,827. Referring to the cottages, would you say, upon the whole, they are as healthy as the cottages in other places?—They are quite as healthy.

16,828. Barking Creek is tidal as far as Ilford, is it not?—Yes.

16,829. What class of population have you living upon each side of the creek?—It is cottage property.

16,830. Are they of a low class or a high class of population?—A low class of labouring population.

16,831. Do you find they are more or less healthy than people of a similar class living in similar places?—They are not more unhealthy; they are much about the same.

16,832. Have you been able, with regard to Barking Creek, to trace any illnesses there to emanations from the creek?—No.

16,833. Have you ever noticed any smell from the sewage in the river?—I have not noticed any smell at Barking nor at East Ham.

16,834. Have you noticed smells from other sources?—Yes, we have various smells from factories in that neighbourhood.

16,835. (*Chairman.*) Your answer imported rather that you had smelt the river?—By Lawes' factory, close to the outfall, of course you can smell it there when the sewage is coming out.

16,836. That is to say, at Lawes' factory?—Yes, when you are close to the outfall, but not at Barking.

16,837. Have you ever noticed the water at Barking at high water to see whether it indicated the presence of sewage?—I have never noticed any such indication.

16,838. (*Mr. Norman Bazalgette.*) Do you remember upon the night of the "Princess Alice" accident a number of bodies being brought ashore at Lawes' works?—Yes.

16,839. Were you there at the time?—I was there about an hour afterwards.

16,840. Did you see the bodies as they were brought ashore?—I saw a number of them.

16,841. Did you observe anything unusual about them?—No, I did not.

16,842. Had you in the course of your practice seen drowned bodies previously to having seen those?—Yes.

16,843. Did these present a different appearance from bodies which you had seen upon other occasions?—No.

16,844. (*Chairman.*) Did their clothes look different from the clothes in the ordinary way upon drowned people?—I did not notice anything different.

16,845. (*Mr. Norman Bazalgette.*) I believe you know that a certain number who were brought ashore upon that occasion recovered?—Yes, I do.

16,846. Can you tell us from your experience as a doctor what they were apparently suffering from; whether it was from the effects of immersion or from anything else?—They were suffering from the immersion or accident.

16,847. How many did you see of them?—I saw about 30.

16,848. (*Chairman.*) Who recovered?—They were landed alive at the creek.

(*Mr. Norman Bazalgette.*) And they seemed to be suffering only from the effects of immersion?

(*Chairman.*) I do not see what else they could have been suffering from, because the fish are suffocated from the want of oxygen, but the human beings were not suffocated in that way.

16,849. (*Mr. Norman Bazalgette.*) Where they apparently suffering from sewage poisoning?—No.

16,850. (*Chairman.*) Did you ever see any symptoms of sewage poisoning in anyone under those circumstances?—No.

16,851. What sewage poisoning have you seen?—I have seen zymotic diseases caused by sewer gas, and I have seen poisoning by sulphuretted hydrogen.

16,852. Would that produce sudden death?—No, a comatose condition previous to death or recovery.

16,853. But it would be within a few hours?—Yes.

Cross-examined by Mr. Beaumont Morice.

16,854. How close to the river do you live?—I live about a mile and a half from the Thames.

16,855. And your district extends along the river, does it not?—Yes.

16,856. What is the number of persons you have in your district?—Do you refer to East Ham?

16,857. Yes?—9,000.

16,858. You say you have not had much zymotic disease?—Not much.

16,859. Did you have an outbreak in 1872?—I was not in the district in 1872.

16,860. Up to how far back do you go?—1874.

16,861. In 1875, do you remember an outbreak then in East Ham?—There was some scarlet fever about that year.

16,862. Was there much?—I cannot give you the details, but I remember there was a good deal of scarlet fever about then.

16,863. (*Chairman.*) In what part of East Ham was that?—All over the district. I knew nothing of the river portion at that time.

16,864. (*Mr. Beaumont Morice.*) Within what distance from the river was this outbreak?—The scarlet fever I saw was all in the upper part of the district.

16,865. How far was that from the river?—The nearest portion I knew anything of was about half a mile from the river.

16,866. (*Chairman.*) Did you hear that that extended to the river?—It would naturally.

16,867. (*Mr. Beaumont Morice.*) You did not know anything about it at that time?—No.

16,868. But it might have been there?—It might have been there.

16,869. Was there any outbreak in Barking town in 1875?—That was at the same time; the epidemic extended over the whole of the district.

16,870. May I take it that there was a very high zymotic death rate in Barking town at the time?—Yes, there was in the town.

16,871. (*Chairman.*) Was it confined to the town?—No, it extended over the whole district of West Ham and into the country.

16,872. Do you know where it first appeared?—I think it came down to Barking from London, if I remember rightly.

(*Chairman.*) I have lived for nearly 22 years in a very sparsely populated part of Kent, where we have no sewage happily, at least no public sewage; each gets rid of his own as best he can, and, upon my word, I think I hear every three or four years of an outbreak of scarlet fever.

(*Mr. Beaumont Morice.*) It differs in degree, I think.

(*Chairman.*) I believe it is amongst children principally, and that they do not die of it very much, but still it exists.

16,873. (*Mr. Beaumont Morice to the witness.*) I was putting to you the high death rate; now do you remember another outbreak in Barking Town in 1879?—There was an outbreak about that time, but I thought it was rather later than that.

16,874. The zymotic death rate was high in 1879 and 1880; may I take both years?—Yes, you may take both years.

16,875. Do you remember what particular diseases were prevalent then?—Scarlet fever and diarrhœa.

16,876. Did that extend to East Ham as well?—It extended to East Ham as well.

16,877. Did you have any outbreak at all last year?—No.

16,878. I may take it that a large portion of your district is from half a mile to a mile from the river; is that so?—The greater portion of it is much more than that.

16,879. But a large portion of it is about that?—50 of those houses are close to the river; the rest are a mile away or so.

16,880. You mentioned about the smell at Lawes' factory; do you go near the river in the course of your duties, except in that particular part?—Not very often.

16,881. Have you been able to distinguish the smell of the sewage from other smells?—Yes, I have once or twice; it is not a thing I have paid much attention to.

16,882. But, residing in the district, would you be able, if you smelt the sewage, to distinguish it from other smells?—I think so.

16,883. With regard to those bodies which came ashore from the "Princess Alice," you say happily 30 persons recovered; how soon after the accident did you see them?—A little over an hour; perhaps an hour and a quarter.

16,884. They had been at once taken out, and brought over?—Yes.

16,885. Do you say you have never known or heard of a case of death being caused by sewage in the river?—By drowning in sewage, do you mean?

16,886. I mean death accelerated by being in the sewage of the river?—I do not know of any such case, and I have never seen one.

16,887. May I ask you, as a medical man, whether, if a person were immersed in a river in which sewage were prevalent, it would tend to accelerate his death, that is to say, diminish his chance of recovery. The reason I ask that question is that at the time of the "Princess Alice" accident there was a large amount of medical evidence that death was accelerated in consequence of the sewage fouled in the river. I ask you, as a medical gentleman, what is your opinion?—Death would be more readily induced by drowning in sewage than by drowning in water.

(*Sir John Coode.*) But the question means by drowning in the Thames, and its then condition, not by drowning in sewage.

(*Witness.*) I should not think so; there was no active gas being given off at the time, as far as I know.

16,888. (*Mr. Beaumont Morice.*) You remember the "Princess Alice" inquest, do you remember it was seriously contended then by medical persons that it would have that effect?—Yes.

16,889. (*Chairman.*) Which side called them?—I do not know. I was not present at the inquest.

(*Sir John Coode.*) The friends of the drowned persons produced the evidence.

(*Chairman.*) If the "Princess Alice" people called them to show they were killed by the sewage and not by drowning, that is one thing.

(*Mr. Beaumont Morice.*) No; those witnesses were called by the friends at the latter part of the inquiry.

(*Chairman.*) With what object?

(*Mr. Beaumont Morice.*) To show the state of the river, for one reason.

(*Chairman.*) To make a claim against the Metropolitan Board of Works?

(*Mr. Beaumont Morice.*) I do not know that.

Examined by the Commission.

16,890. (*Chairman.*) You say 30 recovered of those who were rescued?—Yes, they did.

16,891. A great many, unhappily, did not recover, and were killed?—Yes.

16,892. What was the cause of their death; drowning?—There were about 18 bodies brought ashore dead at the works, and two only of those who were landed alive died afterwards; one was the case of the fracture of the breast bone, and one was the case of an old lady who had been immersed in the water some time, and never recovered from the shock.

16,893. Those two people were not drowned properly; but were the other 18 people drowned; drowning, as I understand, is suffocation?—Yes.

16,894. But it differs from other suffocations, I think I am right in saying, in one symptom, viz., that there is always a frothy appearance. I forget whether it is of the mouth or of the lungs?—At the mouth it exudes a little.

16,895. Were those people drowned?—Upon the bodies that I saw, that were landed dead, I noticed the froth about the mouth and nose.

16,896. Then they were drowned?—I believe so.

16,897. Just as much as if they had been immersed in pure water?—I think so.

16,898. It is difficult for you to answer a question as to whether sewage in the water would facilitate drowning; I should think very likely it would in this way, that a man, instead of swimming efficaciously to save himself, might be so affected by the filthy smell that he could not do his best to save himself; but did you see any symptoms to show, except so far as that might be the case, that the sewage in the water had specifically affected the people's lives?—I did not.

16,899. *Mr. Beaumont Morice* (*through the Chairman*). May I ask whether you saw any bodies some considerable time after they had been in the water; that is to say, after this accident?—Yes, I did.

16,900. In what condition were they?—About as you would expect from the length of time after death. I did not notice that they decomposed more rapidly than I have seen to be the case in other bodies which have been drowned.

16,901. Was there any difference between those and what you would find in an ordinary river, a pure river?—Not that I could notice.

*Mr. H. H. Mason.*
27 June 1883.

16,902. (*Chairman.*) Have you seen many drowned persons besides those drowned at the time of the "Princess Alice" accident?—Occasionally I do; three or four in the year perhaps.

16,903. In the river?—Yes, in the river or in the Creek.

16,904. (*Dr. Stevenson.*) In the case of such an accident, would not the existence of sewage in the water rather manifest itself in those who recovered than in those who were drowned?—Yes; I should say so, if there were any deleterious matters given off from the sewage.

16,905. Did you observe any such cases of what I might call retarded recovery?—I did not.

16,906. Does your district abut directly upon the river for the whole of its extent, or does a part of Kent intervene?—There is a part of Kent intervenes in which the outfall is situated.

16,907. That would cut out a large portion of your district from the river, from the Woolwich ferry up to the Creek almost?—Yes.

16,908. Therefore yours is not a riverine district altogether, it does not abut upon the river directly?—Yes, it does, except for this small portion of Kent.

16,909. (*Colonel Ewart.*) With regard to your evidence about sickness at Barking, is Barking a sewered town?—There is a sewer there.

16,910. But are there not a large number of cess-pools there?—There are a good many.

16,911. And there were at the time of the sickness of which you have spoken?—Yes, more than there are now.

16,912. What water supplies Barking?—The Grays works: the chalk water.

16,913. Do the people all, or generally speaking, get their supply from that source?—They nearly all do now, but they did not at that time.

16,914. (*Sir John Coode.*) Are you aware that at the time of the "Princess Alice" disaster a great deal of discussion arose about the extent to which the deaths were caused by reason of the sewage; was your attention directed particularly to the symptoms exhibited by the bodies that were found; I gather that it was?—It was.

16,915. I gather that, though your attention was particularly directed to the subject, you saw no different symptoms from what you would have expected to find in bodies drowned in pure water?—I am clear as to that.

16,916. Are the Beckton Gas Works within your district?—Yes.

16,917. Are the men there healthy, up to the average?—Yes, for the class of men, and the way in which they live.

16,918. You said that the 200 men at Lawes' works were living upon the banks of the river, you did not mean that literally, did you?—The factory is situated upon the bank of the river, or a little way back, and the houses are situated about 20 yards from the river wall.

16,919. How far does the factory extend back?—I should say the extreme point of the factory goes about 150 yards from the river bank.

16,920. Then both the factory and the dwellings are very close, really, to the sewage margin, are they?—Yes, and I ought to say that the population of 200 includes men, women, and children.

The witness withdrew.

(*Mr. Michael.*) That is our case, my Lord.

Adjourned to Monday, 9th July, at half past 12 o'clock.

# FORTY-FIFTH DAY.

## Monday, 9th July 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
JAMES ABERNETHY, Esq., F.R.S.E., Mem. Inst. C.E.
WILLIAM POLE, Esq., F.R.S., *Secretary.*

9 *July* 1883.

(*Mr. Bidder.*) I am told there was some inquiry made at the last meeting of the Commission, and that Sir Joseph Bazalgette was to inform the Commission as to whether there was or was not an overflow upon the 26th of May at the Blackfriars storm overflow, and Sir Joseph Bazalgette has written a letter to Mr. Ward, which perhaps I may read, giving all the information he has in his possession. "I had made "inquiry and found that there was no overflow on the "26th of May last at any of the five storm outlets at "which records are kept, viz., the River Lee, Western "Pumping Station, Deptford Creek, Office Outlet, "and Falcon Brook Outlet, and my assistant stated "that he believed there had been none at any of the "other outlets. I have, however, since ascertained "that there was a discharge at the Fleet storm over-"flow, Blackfriars, on that day for 1½ hours, between "11.30 a.m. and 1 p.m., and again for a short time "after 8 o'clock in the evening."

(*Chairman.*) I can only repeat that I am utterly at a loss to see what bearing it has upon the question; it only shows that there must have been some specialty with that particular overflow.

(*Mr. Bidder.*) Now, my Lord, in addressing the Commission, and undertaking what I confess seems to me to be rather an onerous task in attempting to do anything in the way of summing up this gigantic pile of evidence that you have before you, it seems to me that it would be perfectly hopeless for me, and utterly wearisome and useless for you, if I were to endeavour to analyse that mass of evidence in detail. The question, as I understand it, which the Commission have to consider is, whether the outfalls of the Metropolitan Board of Works cause a nuisance of such a character as to warrant your recommending a change of system, and it seems to me, in discussing that question, that there is a great deal which has been put upon the notes by way of evidence which I may fairly put aside, and which I cannot help thinking the Commission may put aside, as being irrelevant to the real question that you have to determine. For instance, there was a certain amount of evidence as to

sewage being at times let out upon the flood before high water, and floating up above the outlets. I do not deny that that has been done from time to time: you know why. Because of the insufficient reservoir power upon certain occasions when there has been a rainfall; but inasmuch as you also know that plans are already prepared and have been penned up, only pending the resolution at which this Commission may arrive, I think that may also be put aside. I say it is the intention of the Metropolitan Board of Works to execute works there which would prevent its happening in the future. Then I may put aside also, I fancy, the question of any effect produced by the occasional overflows from the storm outlets—in the first place, because their action is rare; it is a very exceptional thing; and although Mr. Baldwin Latham produced a great many reasons to lead you to conclude that they must overflow when any appreciable amount of rain fell, in point of fact, the evidence shows that his conclusions are mistaken. Sir Joseph Bazalgette has given you the records taken at the principal outfalls, which show you that about 20 times in the year these overflows do occur; they are manifestly occurrences of a very exceptional character, and besides that, *ex hypothesi*, when they do occur, that which overflows is not ordinary sewage, but is matter in a very dilute condition. Further than that, the expenditure which would be requisite in order to abolish these overflows would be something gigantic. I think Sir Joseph Bazalgette has put it at 7,000,000*l.* or 8,000,000*l.*, altogether out of the question in proportion to the damage alleged to be done by them. And then, more than that, the removal of the sewage to the Maplin Sands would not get rid of the storm overflows at all. Then, again, I think I may also put aside a great deal of what was given in evidence by Mr. Baldwin Latham as regards what were the views, ideas, and intentions of those who matured this scheme and antecedent schemes some 30 years ago, as to whether at that time they contemplated the population which is now existing in London or not. It does seem to me that Mr. Baldwin Latham is altogether wrong, because Sir Joseph Bazalgette has completely shown that those points which were made by Mr. Baldwin Latham were fully foreseen, discussed, and considered; but whether that was so or not, the question is whether the sewers being where they are and what they are, they are in fact a nuisance. It seems to me, therefore, that that question is irrelevant, and rather partakes of the character of microscopic criticisms which one may fairly and reasonably decline to join issue upon.

Now, coming to the question as to whether there is such a substantial nuisance caused by the sewers of the Board as to warrant this Commission in making a change of system, I think it is very important to notice, in the first place, with the present state of scientific knowledge, that change of system means one thing, and one thing only; that is, carrying the sewage further down the river or else further out to sea. What may be invented in the future, heaven knows, but I think I am justified in saying that nobody at present can point to any mode of dealing with the sewage of such a gigantic city as London in any other way than that of taking it out to sea. Therefore the question narrows itself into leaving the sewers where they are, or recommending that they should be carried somewhere else

(*Chairman.*) I think we ought to tell you that we have not gone into the question of a remedy. We have had no witnesses upon that subject; we have no trustworthy facts before us. The question is, whether it is a nuisance. I have felt myself a difficulty which you will probably feel. You would not deny that there are things it would be desirable to get rid of if it could be done with the wave of a wand. Then the difficulty is to state the extent of the nuisance. We are now dealing with the first question: is there any, and if so what, quantity of nuisance? It is extremely difficult to define it. Is it "very very bad," or only "very bad," or "all bad," or what?

(*Mr. Bidder.*) Or "rather bad"—quite so, my Lord. I do not want to discuss at all the former question. I am quite aware that in the present stage of the Commission you have not entertained the question of an alternative; but I think it bears upon the discussion of the present case to keep in view the fact which I think I am entitled to put forward as a proposition, namely, that having regard to London and London sewage, nobody will venture to say that it can do anything but go either into the river or into the sea; that is to say, supposing the nuisance were ever so bad, you cannot by a wand either abolish the population of London or make them cease to produce sewage; and I venture to say that nobody under the present state of knowledge can point to any other way of getting rid of it. And I refer to that for this reason, because I want to repeat, if you will forgive me doing so, one point to which I drew your attention in my remarks at the outset of the case, and that is this:—to ask you to distinguish between what I call, immediate local effect of the pouring out of the sewage, and its general effect upon the river. When I use the phrase, the "immediate local effect," I mean its effect within a quarter of a mile or half a mile of the place where it is poured into the river, and I make that distinction, because I say it is manifest, however you pour the sewage in, an immediate local effect, whatever it is, must be produced—there is no help for it. Then people may say it would be very much better that the sewage were down at Gravesend or anywhere else; but if it were down below Gravesend, wherever you went, I venture to say it is clear you would produce that immediate local effect, and there is good reason to apprehend, judging from the evidence of the chemists, that it would be worse there rather than better, because there appears to be reason to gather from the evidence that when the proportion of the sea water is larger than it is at the outfalls, the nuisance would be worse than it is.

(*Chairman.*) Has that been stated by the witnesses?

(*Sir John Coode.*) I think it is well recognised.

(*Mr. Bidder.*) I think it is a well recognised fact that the more salt the water into which you pour the sewage the more offensive the result. Now your Lordship sees why I make the distinction between the two classes of effect. Whatever importance is attached to the immediate local effect, it is not to be supposed that by moving the sewage to another place you would get rid of it—you would only move it to another place, and by moving it to another place you would probably make it rather worse than it is at present.

Now it becomes important to notice what one might guess, and what one knows from what one has been told by Sir Joseph Bazalgette, that at the time these outfalls were designed, these very sites at Barking and Crossness were specially selected after a very great deal of anxious consideration, and surveys of the river, by engineers and others, for the very reason that they appeared to be pre-eminently places suitable for such a purpose, because they were places already devoted to stinks and evil odours and manufactories that could not be tolerated in any other neighbourhood; and I think we have it in evidence here that, in point of fact, for very many miles around—anywhere—I should say, up and down the river, it would be difficult to find a place so suitable in that respect—so free from population to be affected by the immediate nuisance, if nuisance it be, as this.

Now, speaking first with regard to that immediate local nuisance or local effect, what does it amount to? Nobody denies, in fact, I presume, the Commission saw for themselves, when they saw the sewage coming out, that that is a nasty offensive black stream, and that stream can be traced by the eye a certain distance, some people say as far as half a mile, others go as far as to say a mile, there is a very nasty smell which you can trace by the nose, but which many of the witnesses I have called before you say confines

9 July 1883.

itself to about 100 or 200 yards; at any rate, as a rule, it is very limited in its area, and though I shall have to discuss evidence which will be of a different bearing presently, I cannot help thinking that the result of it all comes to this—that really the perceptible and immediate effect of the sewage is confined to a very limited area; it may be taken to be from half to three-quarters of a mile from the point of outfall. There has been a great deal of discrepancy in the evidence I know, but fortunately it has not been a discrepancy of evidence like that in running down cases in which your Lordship has had considerable experience, in which there is always, and always must be, a considerable difference of opinion; but here is a case in which your Lordship and the Commission can go for yourselves and judge by the effect upon your own senses what is the effect of the sewage, and whether it is immediate or not.

Now, therefore, I pass from that to go to that which appears to me to be more important, and to the attempt to prove which the great strength of my learned friends has been directed, namely, the great pollution of the river, not only at Crossness and Barking immediately, but for many miles up and down, creating a state of things which is prejudicial to the health of the inhabitants, and prejudicial to their comfort and enjoyment of life. Now there are two classes of evidence before your Lordship: there is scientific evidence and there is non-scientific evidence; there is scientific evidence of a theoretical character and scientific evidence of the results of observation. You have had engineers; you have had chemists; you have had microscopists; you have had doctors and sanitary witnesses; and I think, perhaps, it will be convenient if I take them separately. I am not going to attempt to weary your Lordship and the Commission by, as I said, discussing that evidence in detail, but discussing the general considerations, and drawing one or two inferences from them. Now, taking the engineering evidence first, which has been directed, firstly, to the pollution of the water, and, secondly, of the mud. It is convenient to distinguish them in that way. You have had four gentlemen, I think, called by the City, Mr. Baldwin Latham, Mr. Mansergh, Professor Unwin, and Mr. Birch. They have laid before you certain tables which I venture to say are purely speculative and theoretical and based, upon assumptions which I think it is not difficult to show are purely fallacious. It is a curious thing to notice, to begin with, that all these gentlemen having erected their edifices upon the same foundation and of the same materials have arrived at results which are discordant amongst themselves to the extent of 27 per cent., and even 44 per cent. of the total, representing the amount of sewage and the amount of pollution in the river.

It is a little startling from what one would imagine was an exact science to find such descrepant results, but I do not think it is so startling as the unsubstantiality of the bases when you come to examine them. Now take the results of the tables put in by those gentlemen; they are all based upon one principle. Their object is to show, viewing it from an engineer's point of view as a purely mechanical question, what is the condition of the river and what is the amount of sewage in the river at different parts of its length; and the principle upon which they arrive at their conclusion is based upon certain observations of a thing which I am almost afraid to name in your Lordship's presence; viz., chlorine from which they deduce all these results. Put shortly it is this. We know the amount of water in each section of the river at high and at low water; I think one may assume that they do know that approximately. We can estimate, say they, the amount of that which is salt; that it is to say, the proportion of that which is sea water as distinguished from fresh water and sewage mixed together, by arguing from Professors Way's chlorine test. The argument is a very simple one, and I am not going to say that if the premises were correct, the result would not be correct. Sea water contains, say they, about 1961 parts in 100,000, fresh water an infinitesimal quantity, and sewage a little more, but still, as compared to sea water, an infinitesimal quantity. If you get, say they, at a certain part of the river a thousand parts of chlorine, you may at once conclude with very approximate accuracy that nearly half of that is sea water, because nothing else would produce that amount of chlorine, and I am not prepared to deny for a minute that, if you get the amount of percentage of chlorine in sea water, and that result, that that would not be correct. The first thing is the percentage of sea water in the mixture, the next thing is either fresh water or sewage—that is obvious; the next thing is to find, of that quantity, how much is fresh water, and how much is sewage or polluting matter, and that is arrived at in this way: We know, say they, the number of gallons of sewage you are discharging from the outfalls on any given day, and we know the amount of water that goes over Teddington Weir and from the other tributaries upon any given day; the proportion between those two represents the proportion in which the mixture in any part of the river is made up of fresh water and sewage; and therefore, that being a known proportion, we can divide the remainder, which is not sea water, into fresh water and sewage, and we can put these figures down upon the table and tell the Commission that there is that quantity of sewage in any particular part of the river. But that is not all we know; they say there is an immense amount of water going down every tide, and much of that returning. To put it shortly, half the water above Southend at high water has gone out at low water; they assume also a rather startling assumption, that the water which goes out to sea beyond Southend always comes back again, not other water, but the same water. Now just let me say a word or two with regard to these two assumptions.

First, very shortly, with regard to chlorine, all I have to say is this, that it is manifest, upon the face of the analyses and tables which they have put in themselves, that nothing is more uncertain and more variable from hour to hour and minute to minute than the result of any attempt to ascertain the amount of chlorine in the river; the results are uncertain to an enormous extent. I will only refer to one table to show you that, and it is quite enough. I will ask you to look to Table No. 15, put in by Dr. Tidy, which is headed "Analysis of samples of Thames water collected "at All Hallows Pier," on a certain day in August last year, and taken at consecutive hours. Now, of course, what you ought to have, if the chlorine followed a regular law, would be that at high water you ought to have the most chlorine, and at low water you ought to have the least chlorine, and there ought to be a gradual diminution of the chlorine from one to the other, and a gradual increase from low to high water. Now, if you look at the table at between 3 and 5, it being high water at half past 3, there are two analyses which give 151 parts of chlorine per 100,000. Then there is a sample taken at 7, and the chlorine has dropped to 64·8; that is right enough, because the tide is falling. Then there is a sample taken at 9 o'clock, when it was dead low water; the chlorine, instead of dropping, as it ought to do, has jumped up to 144, or nearly what it was at high water; and then at 11 o'clock, two hours afterwards, when it ought to be getting rather bigger, it has dropped down to 5. There is another at Crossness, which is equally startling, it shows similar eccentricities. I will refer to Table No. 7, samples of sewage water collected at Crossness outfall.

(*Chairman.*) Just let me ask you this—does this bear upon the great question of below bridge?

(*Mr. Bidder.*) It bears upon all the engineers' tables. I only want to show the Commission that it is impossible to trust to the analysis of chlorine, that it fluctuates in such a wild manner, whether it is owing to the or not I do not know, but it is perfectly hopeless to base anything upon it. And remember that it is the sub-structure of the whole of the evidence

of the engineers. I have no doubt for a moment that these samples are taken with perfect fairness and care and properly analysed, and that they really represent what was the case at that spot, at that particular moment.

(*Chairman.*) How on earth does it prove anything? I suppose the size of the river would tell you what quantity of water would flow in, and what flows down is known by gauging Teddington Weir, and the quantity of sewage is known.

(*Mr. Bidder.*) I am showing you that their system is a fallacious one—there is a certain volume of water in a certain reach, and these gentlemen profess to be able to tell you how many days' sewage there are in each block.

(*Chairman.*) They surmise that the water which has come back into the river has been already polluted, and that therefore there would not be such a dilution as if it were all fresh sea water which came in.

(*Mr. Bidder.*) I am upon a step before that; take any part of the river; we know there are three things: that there is a certain amount of fresh water which is coming over Teddington Weir; there is certainly sea water, but it is brackish; and there is sewage, and they want to know the proportion of the sewage. Now, to begin with, they ascertain that a portion of sea water will contain, say, 2,000 parts of chlorine. The river water and the sewage have so little that you may say that they have practically none compared to sea water. If you found a water at Erith which contained 1000 parts of chlorine, you could say unhesitatingly that that water is half sea water, whether it has fresh come from the sea, or whether it has been in the river a month; it must be a mixture which must be half sea water; and that is a statement I do not find any fault with whatever, if their figures are right. From that, they profess to show that the residue must be sewage and fresh water mixed together, and though I admit that Professor Way and the gentlemen who made the analyses are perfectly right in the analyses and figures upon which they based their superstructure, yet, whether it is that the salt water comes up in streaks or is unequally diffused, or that at times it is more salt and at times more brackish, I do not know; but, as a matter of fact, you cannot trust to one specimen of the river to represent the condition of the water at that spot five minutes afterwards. Therefore, to argue over a five mile reach, as they do, from a single sample, or a couple of samples, is perfectly illusory, as I submit.

Now I have Table 7 of Dr. Tidy's before me; it refers to All Hallows Pier, at high water; you recollect it is the saltest, it has most chlorine in it, and it is lowest at low water, when there is the least chlorine. That table contains a series of samples of sewage water collected at Crossness, taken hourly; evidently it is not the sewage taken at the outfall, but water in the river, because the outfall never contains chlorine to this extent; it contains scarcely any. Now you are told that it was high water at about half past eleven, therefore the samples, as you will see, began after high water, when the chlorine ought to diminish as the tide ebbs, because the water gets fresher. Now, beginning at half an hour after mid-day, you find 208–80; an hour later, and you find nearly double, 367; an hour later, you find 151; an hour later, and it has jumped up to 266. Now, without going further, these, I have no doubt, are perfectly fairly taken samples, you have the chlorine jumping about, doubling where it ought to diminish, and diminishing where it ought to be double. I merely mention that to show what a flimsy thing that is upon which to base such a superstructure as these tables profess to show.

Now I pass from that to show the assumption the other side seem to adopt, which seems to me to be equally erroneous, and that is the strength of the sea water. Now if, as your Lordship put it, supposing sea water contains 2000 parts, and that your mixture contains only 1000, your conclusion is that it is only one-half sea water; but if it is 1500, your mixture is two-thirds sea water. Now there is no doubt in my mind that they have given you sea water as much too strong. Dr. Tidy has given his analysis of sea water all over the world, and this astonishing result that they have given is that the Southend water, which they have gone by, appears to be stronger than the water in any other part of the world, with the exception of the Dead Sea; much salter than the Mid-Atlantic; that is to say, taking the standard which they have taken. But that is not all; upon certain of the days upon which the calculations were made we have given us by Professor Way, what was the actual standard of the water, not only at Southend, but at Margate; and it is very far below the figure which they have assumed. Upon one day, when they assume the proportion of chlorine to be 1961, it actually was at Margate 1770, which very materially alters the conclusions to which they have come. I know what the other side will say, that at Margate it was 1770 because that had been after a fresh which had diluted it. That clearly shows that the Thames is diluted with fresh water, for the North Sea has a great number of rivers running into it, and it therefore is not likely to have as much salt in it as the Atlantic, which has less rivers running into it in proportion; but, whatever it is, that which feeds the Thames is the sea water outside it, whether it be weak or strong.

Now the next hypothesis is a most astounding one, and, I venture to say, the most fallacious of all, and that is, having cometo the conclusion that there is a certain residuum which is made up of fresh water and sewage, in order to arrive at the proportion of that which is fresh water and the proportion which is sewage, they say we have only to look at the amount of sewage that you were pouring into the river upon that day, and the amount of fresh water which was coming over Teddington Weir upon that day, and, whatever is the proportion between those two, that represents the proportion of those constituents, fresh water and sewage, in that residuum,a most astounding proposition to arrive at. The sewage to a certain extent varies every day in amount and extent, and so does the water in Teddington Weir vary in amount and extent every day. We are not talking of the amount of sewage which has been found upon any particular day; there is upon their assumption something like 40 days' sewage in the river, yet all the way down to Southend, although the sewage was shot into the river a month before, and the amount of fresh water that is passing out at Southend had come in a month before, yet the proportions in the river upon that particular day are determined by them by the quantity coming in at Teddington Weir and from the outfalls upon that particular day. One witness went as far as to say that, if you put in a quart of fresh water at Teddington, another quart was pushed out at the other end immediately.

Now the facts are that, though eventually it flows out at the other end, yet it has to perform a certain number of oscillations up and down; and another thing is that, when you are talking of the lower reaches (assuming you have affected the amount of fresh water pushed down into the lower reaches of the river), that which you have pushed down is not the thing which you have put in above; and I ventured to illustrate that by saying that, if you had a long passage full of people, though you might push a man in at one end, it does not follow that a man will come out at the other, it might be a woman.

Now the case is capable of *reductio ad absurdum* in this way. Suppose the quantity of sewage flowing into the river is constant, and that you have twenty times the amount of water coming over Teddington Weir to that of the sewage, then they say that upon that day, all the way down to the sea, whatever is no sea water, is 20 parts fresh water and one part sewage Now suppose to-morrow the flood is over, and the fresh water has dropped to 10, then they say that all the way down the river the water in each block is 10 parts fresh water and one part sewage. If, for instance,

9 July 1883.

to-day there is 20 times as much water coming over Teddington Weir as sewage, and from that they deduce that in the tidal estuary there are 30 days' sewage, and that to-morrow it falls to half, they would say there are 60 days' sewage in the river and if the next day it fell to a quarter, they would tell you there were 120 days' sewage in the river. It is absurd to say that the proportion of the sewage in the river is determined by its momentary relation to the two sources of supply.

Then there is another thing equally fallacious, as it seems to me, the assumption that the same water which goes to sea past Southend comes back. As they told your Lordship, of all the water that is above Southend at high water half goes seaward of Southend at low water, and with it, of course, half of the sewage in the river. Upon the next high water there comes back water which fills the tidal area again, and they assume that that comes back with exactly the same mixture as it went out; but, in point of fact, although they admit the mixing action all the way down the river, which they admit is accelerating the motion of the sewage seaward to Southend, they assume that that stops at Southend, and that whatever had passed to Southend would come back again.

(*Chairman.*) As I understand, the effect of that argument would be that ultimately the river would be filled with Teddington water and sewage with no salt water in it.

(*Mr. Bidder.*) I really think it would come to that. Southend Pier seems to be the arbitrary point that they take; but if that is so, it would have been good at any other point, if they had taken Margate, for instance. But the strange thing is, when they were arguing to support the excessive saltness of the river at Southend, they took exactly the opposite view, because, I recollect, in answer to a question from Sir P. Benson Maxwell, I suggested that it was not likely that the water at Southend would be such very salt water; but I was told, "Yes, because the high "water at Southend comes in from the north; it is "fresh sea water; you must not assume that it is the "fresh water coming back again." Perhaps I had better give the Commission the reference to that. I was cross-examining Dr. Tidy as to how on earth he made out that the water was so salt, and Mr. Abernethy asked the question at 10,153,—"You see it is a very "large funnel-shaped mouth, and that the tide comes "in from the North Sea; would you expect to find "much fresh water?" To which the witness replied, "No, I should not. As a matter of fact, I should "expect to find very little.' That is rather inconsistent with the hypothesis that all the polluted mixture that comes out is carefully preserved in some mysterious way beyond Southend, and comes back as it went out. Therefore it does seem to me that every one of these hypotheses is open to the most serious objection, the fundamental one of all, the chlorine test, being, as I have shown, whatever the accuracy of doing it, utterly unreliable.

But there is one hypothesis which I must not lose sight of, which is, perhaps, the most important of all in considering what practical value to give to the engineers' evidence; that is, once sewage always sewage. Everybody round the table admits that there is a constant destruction going on, and that the sewage is completely destroyed whereas the gentlemen here say that, once sewage, always sewage; that no particle of it is ever lost; no particle is ever decomposed; that it is always sewage, and is always unaltered; that is their hypothesis. Now that is so obviously entirely ignoring one of the principal factors in this case, admitted on both sides, that it seems to me to dispose of the engineering evidence altogether.

Now, my Lord, there is only one other question, I think, touched upon by the engineers, which I need deal with before I pass to the chemical evidence, a sort of suggestion which was made—I do not think it was relied upon much—that we might be doing mischief by contaminating the chalk wells, because it was argued with perfect truth that wells near the river do fluctuate in their level with the tides, a perfectly true principle in hydraulics; and Mr. Baldwin Latham pointed to the chalk well at Grays, as to which he seemed to draw the inference that the chlorine found in it must have been derived from the river. Now Mr. Law has shown you that, so far from that amount of chlorine being unusual, there are numbers of chalk wells given in the Rivers Pollution Commission Report which contain abundantly more, and that it is not an exceptional amount; and furthermore I may point out that there was not a particle of evidence to suggest the slightest trace of sewage contamination in any of them.

Now, my Lord, I pass to the chemical evidence, and I confess I approach it with a great deal of diffidence. I do not pretend to master all the propositions which chemists put before you, I gather from themselves that no man in the present state of science is in a position to give absolute and positive results, or to draw positive deductions as to the amount of sewage present. I think it is admitted on all hands that such results as you do draw must be and can only be relative. You have three tests which have been taken by the chemists who have been called by the Metropolitan Board of Works, all of whom are very eminent men and as well qualified as anybody could be, to speak upon the question. We have three different ways in which we have dealt with the chemical question; one by ascertaining what they call the albuminoid ammonia present in the water. Professor Tidy says that albuminoid ammonia, in his judgment, is not, in a case like this, a trustworthy guide. Sir Frederick Abel and Dr. Dupré say, "as regards the absolute amount of sewage, per-"haps not," but if you conduct your analysis carefully, it is a guide as to the relative amount; so do Dr. Odling and Dr. Voelcker say. The second process which they have adopted is to ascertain, or to infer rather, the amount of putrescible or polluting matter by the amount of oxygen which is required to oxidise it by using permanganate of potash. That also, they say, and I think it is admitted on all hands, if applied under proper circumstances, is as good a test as you could have for relative pollution. Dr. Tidy seems to have some hesitation as to applying it in salt water; but I think I shall be able to show in a minute that it cannot be less reliable than what he has adopted as the test in salt water. But again, I say it is shown to be as good a test as you can have. It would be absurd for one personally to express an opinion upon it, but I will content myself with drawing attention to the evidence. The third process they have adopted is to observe the amount of free oxygen in the river, and to argue from that because there is a certain fairly ascertainable normal amount of free oxygen which the water should have; and, as I understand, when you find that defective it is a distinct indication that what is wanting has been used in burning up some nitrogenous or other organic matter.

Now it is a remarkable thing, and adds greatly to the weight, as it seems to me, to be derived from these observations (I am not going to trouble you with them in detail), that the results arrived at by dealing with the case in these different ways confirm each other remarkably, and, put shortly and generally, for I will not attempt to do more, amount to this. There is a certain amount of impurity in the water even at Teddington though it may be good enough for us; Londoners to drink, as you come down the river, the amount of impurity, gauged by either of those three modes, increases. It arrives at its maximum, they say, pretty nearly at the outfalls (and I will say so too); there it is from $2\frac{1}{2}$ to 3 times as great as it was at Teddington; the amount of impurity then gradually diminishes again until you approach to near Southend, when it has fallen, not only down to, but below what it was at Teddington, and the water is purer than it was when it started at the top of the tidal section.

Now if that be right, I cannot help saying that a total impurity which is only three times that which we consider to be consistent with a good potable water is not a very alarming thing. Of course we are

not speaking of the samples taken at the actual sewage stations, everybody knows that the sewage is far more foul than that; and that, if you went and dipped a can into the river within a few yards of the outfalls, you would get a far more concentrated mixture. I am speaking, not of the particular sewage stream, but of the area of the river down to and beyond the outfalls. Now it does not seem to me that anything like 2½ or 3 times the impurity of the Teddington water is a very terrible thing, not of course for a potable water, because nobody thinks of drinking it, but to live by the side of, and even to bathe in.

Now I will deal with the chemical evidence which was given upon the other side, and here I can only pretend to deal with it in a very general way. But I take Dr. Tidy, who has gone into the matter with the greatest care upon the part of the City, and he does not profess great confidence in two out of the three tests that we have taken, but he is confident in certain other things. I say I think that our tests are strongly confirmed by the fact that they seem to give very nearly identical results with theirs, notwithstanding Dr. Tidy has that doubt. But when you find by one process (which at any rate eminent chemists consider a reliable one) that you get this result: impurity rising from one to three, and then falling to one; and that, when you have a second result which gives you a rise from one to three and then falling to one, and again a third process which gives you a rise of impurity from one to three, and then again a fall to one, I say it seems to me that these are confirmed very strikingly. But Dr. Tidy says, "I prefer to take it "from the amount of organic carbon and organic "nitrogen which I find in the samples," and also he says, not only the "amount," but the "proportion" in which they are present, or, as he calls it, the ratio of the nitrogen to the carbon, because, as he says, "in "the river water as it comes over Teddington Weir "the proportion of nitrogen to carbon is very small; "I think it is only 1 to 8. In sewage the proportion "is very high, and if I find the proportion rises, I "draw the inference of the presence of sewage." Now what vitiates that, and what I see, in looking over the evidence, induced Dr. Frankland to say he gives it up as totally worthless, is this, which Dr. Tidy said he had regard to, but which he did not consider as having affected his results. But there is another thing first which we know to affect the presence of nitrogen, and that is sea water; that the ratio of nitrogen to carbon in sea water is greater than in sewage, so much so that in sea water Dr. Tidy tells us that the nitrogen is actually equal to the carbon in many samples. I took the trouble to trace the subject in this sort of way, and I will just mention, in order that it may be upon the notes, that those members of the Commission who care to test it may do so afterwards. It will be found that Dr. Tidy has given his analysis of sea water. I hope the Commission do not think I am going into too great detail upon this point.

(*Chairman.*) I am afraid I do not appreciate the value of it. I trust you are not troubling yourself with anything above Greenwich.

(*Mr. Bidder.*) No, it is general.

(*Chairman.*) Your drift is to show that the proportion of sewage to actual water in any place which you take is less than the other side would make it.

(*Mr. Bidder.*) That the polluting matter, not that which contains the sewage, but that which would be recognised as contamination, is very minute.

(*Chairman.*) After all, the question is whether it is more or whether it is less, and what does it do when it gets there? If it were double what it is, or if, somehow or other, its evil effects were annihilated, is not what it does the great question we have to consider?

(*Mr. Bidder.*) No doubt; but the two do bear upon each other.

(*Chairman.*) The other side give *a priori* evidence to show that it ought to smell.

(*Mr. Bidder.*) And my evidence goes to show that it would be a miracle if it did smell, except, of course, in the neighbourhood of the outfalls.

(*Chairman.*) After all, we shall have to ascertain whether it does smell, or no.

(*Mr. Bidder.*) There is an analysis given in No. 1 of Dr. Tidy's tables of sea water at Southend, showing that practically the nitrogen and the carbon are equal; each of them is ·3 grains in a gallon, and if you go back to his big table of analyses of samples collected all the way down the river, if you look at the amount of chlorine in any one of the samples and apply the proportion of nitrogen to the carbon, assuming that the chlorine comes up from the sea, and apply that to the chlorine as shown by the sample, that wonderfully modifies his results. But I will not weary the Commission by going into the figures.

Now I should like to refer your Lordship to the first table of Dr. Tidy's, upon which there are one or two remarks that I wish to make; I am endeavouring to avoid detail as far as possible, and one reason is this: because it bears upon the question in this way. We have heard a good deal about stench and offensive appearances and smells in the neighbourhood of Greenwich and Woolwich, in the upper parts of the river. Now if you recollect, Dr. Sorby told you, as the result of his microscopic analyses, that he had discovered a considerable maximum in the neighbourhood of London Bridge, and it becomes a material question whether what is observed in the part of the river above the point of the outfalls is not caused by sources of pollution for which we are not responsible at all. Now I know you were very much startled when Dr. Sorby told you that the water at London Bridge was more polluted than it was at the outfalls; that, gallon for gallon, it was more polluted; that was shown also by Dr. Dupré and Mr. Dibdin; but more than that, it is actually confirmed by Dr. Tidy. I will not weary you by calculating it now: but it was challenged weeks ago, and I say it has never been denied; and therefore may be taken to be absolutely correct. If you take these samples from No. 27, which is at Lambeth, down to No. 35, which is at Deptford, they have far more organic matter in suspension than the samples taken at the outfalls below or above, they are the worst of the whole lot. If you multiply the number of grains of suspended matter by the percentage of organic matter, you would get the number of grains of organic matter. Now take it from me that, if you do that in the case of these samples between Lambeth and Deptford, you get something over four grains of organic matter in suspension per gallon, whereas when you go to the outfalls it is something under two, and in the neighbourhood of Erith it is about one-and a-half, and if you go above, it is under two; in point of fact, the amount of suspended organic matter in that part of the river, from Lambeth to Deptford———

(*Chairman.*) I do not quite follow that; take the sample No. 27 at Doulton's.

(*Mr. Bidder.*) That contains 8·54 grains of suspended matter, of which 66 per cent. are organic matter. Now two-thirds of 8·5 are 5½ grains. Now take No. 45 at Barking outfalls, there are, in that sample, 4 grains of suspended matter to the gallon, of which 31 per cent. are organic. Now some of them are better, and some of them are worse; but, averaging them in that part of the river, you find it is under two grains, and in the part above Deptford it is over four grains.

(*Chairman.*) 5½ you have got it at, at Doulton's.

(*Mr. Bidder.*) Yes, but I do not pretend that that is a fair specimen—that is an exceptionally bad one. There is one as high as six grains of organic matter, that is at the Globe Wharf, No 32.

(*Chairman.*) I confess I do not understand this sort of thing—Putney is 4, and Wandworth is 1·4.

(*Mr. Bidder.*) Putney is 4 grains of suspended matter, of which ⅕th per cent. is organic, which is a little less than a grain.

(*Chairman.*) Below it is one-third of that.

(*Sir John Coode.*) And above, it is three times that.

9 July 1883.

(*Mr. Bidder.*) Therefore it is not fair to take an isolated sample. I take the whole group, and the remarkable thing is that at that very place where Dr. Sorby says he found the maximum of impurity in suspended matter Dr. Tidy says he found the same thing, and you will find the same thing in the diagrams of Mr. Dibdin and Dr. Dupré. The important thing is that that establishes in this inquiry as to whether these things which the gentlemen at the East and West India Docks, and at Woolwich, and at other places, have complained of, have not been caused by things other than the outfalls, that there are impurities above which, gallon for gallon, are worse than the state of things below the outfalls. And let me here notice an observation of Mr. Dibdin's that in 13 out of 20 observations the high water was better than the low, that is to say, that which had come up from the neighbourhood of the outfalls was better than that which had come down from the London Bridge direction. And it is not merely London Bridge: because we know there is the large West Ham sewage in the river Lea, and that is the Bow Creek. There is a very large floating population, which is very important. In some of the evidence to which I shall draw your attention there is shown to be a very large discharge of sewage at North Woolwich, just opposite to the pier. You will find some of the witnesses localise the stench and the offensiveness upon that very shore at North Woolwich, and close to that pier.

But now, my Lord, I will not trouble you with any more detailed figures. After all, what do these analyses show in the way of nuisance? Dr. Tidy himself, when I put the question to him whether, having the advantage of his analyses and having seen the river, he was prepared to say that the river Thames was in any way injurious to health, said he was not prepared to say that it was injurious to health. I put it also to other chemists with the same result, and I may just as well turn to some of the evidence. Neither could he say whether the more objectionable substances were referable to the outfalls.

Now there is a very important point, in fact, the most important question in this cause, which arises upon or is suggested by these analyses; and that is the question of free oxygen, because everybody agrees that the diminution of the oxygen is produced by the burning up of the sewage, and, as Dr. Tidy says, the fact of the diminution of the oxygen is a sure sign that the sewage has been burnt up. And he goes further; he says, all that does not sink must eventually be burnt up.

Now the question is, How far are we justified in saying, as we do, that that is an efficient cause which deals with the bulk of the sewage, and prevents it being anything of a nuisance, except the immediate local nuisance that I spoke of? Now nobody has gone into the question more clearly than Dr. Tidy, and as your Lordship was absent when he was examined, I will take the liberty of reading one or two of his answers, not only given in this inquiry, but also in his books written upon this subject.

(*Chairman.*) I think I know what Dr. Tidy said here, and what he had said before, that, if you turn sewage into a river flowing, in course of time it will become all right.

(*Mr. Bidder.*) He says a great deal more than that—he condescends to state the extent and the amount of the purification. He says, if you put one part of sewage into 20 parts of water, and let it flow for 14 miles, it will in the course of that distance have vanished as sewage. But there are one or two paragraphs in his evidence which are well worth reading, because they bear so entirely upon this question before you. In answer to Question 10491, Dr. Tidy quotes from his pamphlet on river water, and he says, "Let me briefly state my case and then "proceed to call my evidence:—(1.) If sewage be "discharged into running water, the organic impurities "will, I contend, after a flow of a few miles, be entirely "destroyed or got rid of, the water once again "assuming its normal condition of purity. (2.) That "this power of self-purification depends upon three "things: (*a.*) On the *subsidence* of the suspended "impurities brought down by the sewage. Thus in "the course of the river flow the grosser suspended "matters will be left behind. (*b.*) On the presence "of *animal life* in the river. After the water has "assumed a certain degree of purity (for it is not till "then that animal life thrives) the fish in the river "act as river scavengers, and so as general purifying "agents. (7.) On the *oxidation of the organic* "*matter.*" Then he goes on to describe the appearance of sewage in a river where sewage is poured in, which is wonderfully applicable to what we see in the Thames. He says, "The sewage at the outfalls is "probably offensive, very turbid, and more or less "brown, the exact colour and degree of offensiveness "being dependent partly on the character of the "sewage, but chiefly on the distance it has travelled "along the mains before its discharge into the river, "and the extent of exposure it has undergone. "Tracing the sewage stream down the river, it will be "seen to assume a black colour from the formation of "sulphide of iron. A further short distance, and the "black colour perceptibly decreases, and, as we watch "the flow, the blackness, I had almost written yard "by yard, disappears, until at last the river water "exhibits no signs of colour, turbidity, or smell. Once "again, very soon after sewage has been turned into "a river, the sewage fungus, that most absolute "indication of the presence of sewage in any quantity, "makes its appearance in the river. Excepting this, "however, all signs of vegetable life, barring possibly "a few straggling weeds, disappear; no fish, or fish "only of a certain kind, are to be seen. The banks "and river bed become black, and branches of any "trees that by chance dip into the water will be "seen covered with a black flocculent deposit. "A short distance further down the river (and "sometimes a very short distance indeed) the "sewage fungus cannot be found, vegetation "becomes clean and luxuriant, fish are abundant, "and the river banks and the river bed, "seen through the now clean water, show no signs "whatsoever of that black deposit." Now he says that does not apply to the river Thames, but I venture to say it is a most striking description of a great deal of what you see down at the outfalls. I will not trouble you by reading all that he said; but I must read one other paragraph, because it really is so very much in point; he says further on, in answer to Question 10,500, still quoting from his pamphlet, "There is first of all a remarkable fact to be noted in "the analyses of Thames water. The water at "Lechlade may be regarded as having assumed as "nearly as possible the character of river water. "Up to this point it will be conceded that practically "no sewage has found its way into the river. "Between Lechlade and Hampton, a distance of "110 miles, the river received (I am speaking of a "few years ago) the sewage of nearly a million "people. At certain places it is admitted that a "larger quantity of organic matter than was present "at Lechlade could be detected in the water. For "instance, one mile below Reading I have found a "quantity of organic matter at least double that "indicated at Lechlade, but four miles further on the "water was again found to have become normal, "whilst the organic carbon and nitrogen at Hampton, "notwithstanding the sewage of this million of people, "was rather less than at Lechlade. What, I ask, "had become of the sewage of this million people "if it had not been oxidised during the flow of the "river." Mind you, oxidised to such an extent that it was drank. Now it is said that the sewage of that million of people does not go into the river now, but that does not touch the question. Here is the fact that this very water above the locks had received the sewage of a million of people, and that after a short flow it had become sufficiently purified for people to drink. That is the principle upon

which Dr. Tidy has proceeded all his life, and he has summed up his views by saying that, if you take 1 in 20 parts and let it run 14 miles, it will be destroyed. I am quite aware that Dr. Tidy says you must not apply the proportion here, because what you are dealing with is not unpolluted water. But with regard to this particular case Dr. Tidy very frankly does acknowledge: By the time the sewage has arrived at Southend, I am bound to say that I think a great deal of it is mastered. He adds to that: When I say "mastered," I mean "burnt up." I recollect putting it to him at Question 10,568, and I see I quoted it to him from a former inquiry, and it touches it a little more nearly: "Given the state "of the Thames and the brackish water, there "being two hundred volumes of water to one "day's sewage, it will be burnt up, and your "answer was 'yes.'" Then it is curious to note that Dr. Letheby, in his report, which Sir Joseph Bazalgette quoted to the Commission, gives almost precisely the same views. He is speaking of the water at Blackwall, and he says, in answer to Question 12,907, quoting from the report of Dr. Letheby, "It is not "that the proportion of the organic matter decreases, "as will be seen by the tables, but its condition is "altered. This is no doubt occasioned by the action "of the air, and by the agitation of the running "stream, and the fact is amply demonstrated in every "river in the kingdom, especially in those which "receive the sewage of large towns. Those, there-"fore, who have looked upon the soluble sewage of "London as an unchangeable log of wood floating up "and down the river with the movements of the tide "have taken a very erroneous view of the thing, for "so prone is the organic matter to undergo change "and to complete its course of putrefaction that it is "doubtful if it exists as a putrefying body a few "hours after its entrance into the river. In fact, "while it has been traversing the sewers, it has "generally been so much agitated and broken up by "the movements of the current as to be in a very "advanced state of putrefaction." You will recollect that Dr. Tidy says that, in point of fact, in the case of the outfalls, it has gone through its first stage of putrescence before it arrives at the Thames at all, consequently a good deal of what left London as sewage has been turned into gas. Then Dr. Letheby's report goes on, "Almost the whole of the nitrogen has "become changed into ammonia and its sulphur into "sulphuretted hydrogen, and then when it reaches the "Thames it finishes the last stage of its putrefactive "career by the rapid absorption of oxygen and the for-"mation of compounds that are comparatively inert, so "that, partly by means of dilution and partly by the "destructive powers of oxidation, the Thames possesses "the means of self-purification, which is fully equal to "the contaminating injury to which it is at present "exposed." He adds, "I am even of opinion that the "discharge of the sewage into the river in such a way "that it would be diluted with not less than 200 or "300 times its bulk of water during each tide, and in such a manner that the insoluble portions would not "be deposited on the banks, would be a safe and "sufficient means of disposing of it." That is entirely in accordance with Dr. Tidy's views now.

Now, my Lords, Dr. Tidy says that is all very well; if you have got unpolluted river water, you may put in one part in 20, and in 14 miles it would be gone; but yours is not unpolluted water, you have put other sewage into it before. That of course is perfectly true; but instead of putting one part in 20, it has been shown you by the engineers that we put in one part in 260, that is to say, a thirteenth part of that which Dr. Tidy would admit is efficient; and consequently, according to Dr. Tidy's rule, supposing we were to put six and a half days in at once, supposing the water were unpolluted, it would not be too much, and that 6½ days' sewage would be disposed of in the course of that 14 miles. I need not say that it would be disposed of before the 6½ days were gone, because it would have gone in that time over some 300 miles.

Now test it in another way: after all, the agent which Dr. Tidy and Dr. Letheby relied upon for the burning up of sewage is the amount of free oxygen in the river. Professor Way ventured to say it would take 150 tons of oxygen to oxidise the stuff that we put into the water.

Now, upon that, when the figures are given you by Mr. Law and Dr. Dupré, it turns out that you have pretty well double that amount of free oxygen in the water when the water is at its worst. So that, tested in that way, it is true that the water is not unpolluted; but that, tested by the quantity of this purifying ingredient, you have far more than sufficient; and then, more than that, the fact is not disputed. I cannot argue it from Dr. Tidy's table, because it does not go far enough, but I will take you down the river, and when you get to Purfleet you find the water has been sufficient for its work, the purification is completed; and not only that, you have not only the amount of oxygen which is shown to exist in the water, but everybody agrees in saying that the affinity of water for oxygen, when deprived of its normal quantity, is remarkable, so much so that Dr. Tidy says that it is almost impossible, if you do not do your analyses at once, to get accurate analyses, because the water is absorbing and drawing in oxygen on all hands. If I might use a manifestly inappropriate expression, it is a sort of vacuum of oxygen in the river, the more it is short of oxygen, the more greedily it takes it up when it has the opportunity. Professor Way puts that very pointedly, he says there is no doubt that the river does take up oxygen from the air and from every source very rapidly.

(*Chairman.*) It is impossible not to believe what both sides agree to, that is to say, there is a purifying power in the water which, in some proportion, and at some time, will annihilate the sewage; but it is also certain that there is some smell. What we have got to deal with is what is the quantity of nuisance. What you are saying is very relevant for the purpose of showing that, if your clients say it does not smell, that is the reason why it should not; but we all know that. I suppose we are all possessed of that. Then the question is really reduced to this: knowing that there is that cause, to what extent does it operate, is there a nuisance in the river?

(*Mr. Bidder.*) That is the very point I want to make if you will forgive me; it is not enough for my purpose to have it admitted that there is a purifying influence which will do its work at some time or other; but that there is a purifying influence which is sufficient, and which does its work in a very short time indeed; and then, instead of there being many days' sewage in the form of sewage in the river, there is never more than a tide and a half, or a couple of tides, or something of that kind. I try to avoid wearying you with details in reference to figures and analyses, or even with references.

(*Chairman.*) That I understand, but I do not know that I explained myself clearly. Everybody admits that sewage poured into the river will, sooner or later, I suppose, in proportion to the volume of water into which it falls, or the rapidity of the flow of the water, become purified of the sewage; everybody seems to admit that some day it will go a little faster than others; what we have to see is, what does it do at Crossness and Barking; is not that so?

(*Mr. Bidder.*) That is really what I have in my mind, and that is why I venture to say that in this case Dr. Tidy's rule applies, and that practically at the end of, it may be, 14 miles, or a little more or less, the sewage has disappeared.

(*Chairman.*) What do you say to the men who say they smell it fearfully and dreadfully at Woolwich, and fearfully and dreadfully at Purfleet, and that, all the way between, the river is fouled and polluted, and that fish cannot live there?

(*Mr. Bidder.*) I have something to say to that evidence in a very few minutes, if you will let me get rid of this higher atmosphere, in which I confess I am by no means happily at home; but I will draw your

9 July 1883.

attention to this, which I will put as shortly as I can. I merely say that the universal opinion, at all events, the opinion of those best qualified to form a judgment upon this subject, is practically summed up by that statement of Dr. Tidy's that the 1 in 20 proportion for a 14 miles run destroys the sewage altogether.

(*Chairman.*) Let me make a remark to you which I think will show the reasonableness of what I am saying. If I were to pour a quantity of sewage from a watering pot into the river, that would be one thing; every particle of it would be mixed with the purifying water; but if you take the case of a large quantity of sewage going down in a stream and not being touched by the water upon either side of it, that is another thing.

(*Mr. Bidder.*) If it does not mix, it does not get the benefit of the water.

(*Chairman.*) If you were to pour out this sewage into the Gulf Stream or in the Mid-Atlantic, it might smell for a time, but if you were to spread it out by pipes, it would not smell at all. What we have really to deal with is the question of fact. Is it a nuisance to smell and sight, and health and fish, and everything else?

(*Mr. Bidder.*) Of course I am very glad to narrow it down, because I have had in my mind that what has been brought against us is a much wider charge than that. My learned friends have not merely relied upon the old fishermen who have come and said that they smelt a smell, and that it was nasty, but they have suggested injury to health from the water containing contaminating influences which were provocative of disease in places upon the banks of the river both above and below.

(*Chairman.*) I think we may say, as at present advised, that there is no evidence of any kind to that effect. (*After consulting with the other members of the Commission.*) I should not say this unless I had informed myself beforehand. We think that there is no trustworthy evidence that the health of the people is affected by this sewage. Just understand this: you know I do not mean to say that if a man is dredging, and is made sick by this smell, his health may not be indirectly affected; that no one could say. But we are all of opinion that the general health of the people on shore, or the people who go up and down the river, or the lads on board the training ships, or things of that sort, is not affected by it.

(*Mr. Bidder.*) That enables me to curtail this part of my remarks very much. I can put it in this general way that the proportion in which we put the sewage into the river is very far below the purifying power of the river, and that, whether you test it by oxygen, or whether you test it, as Dr. Sorby has done, by the microscope, the actual results obtained confirm the view that the destruction of the sewage is very rapid indeed. Recollect that Dr. Sorby showed you that of what went past him on the ebb only 40 per cent. came back again upon the flood.

Now there is another allegation that, though it may not be very bad now, it is growing worse every year. Now what I have to remark upon that is this. I do not think Dr. Tidy says so, but Dr. Frankland undoubtedly did say so. Now Dr. Frankland had only made one series of analyses, and I suggested to him that, in order to establish progress, you required to be able to compare one period with another; he had not got those means, but his observation was limited to what he could see when going from Charing Cross to Cannon Street across the river by the railway bridge, which he was in the habit of doing daily.

Then I think I could pass by Dr. Frankland's tables of the amount of detritus he supposed to come down the river. I do not think that I need occupy time to show how fallacious these tables are. They are tables based upon this sort of hypothesis, that, whenever $\frac{1}{100}$th of an inch of rain fell in London, that proportion of rain went into the sewers, and with it its due proportion of road side matter and sweepings. If anything turns upon Dr. Frankland's tables, there was this inaccuracy in them that they were based upon old observations of the amount of road sweepings which used to go down through the outfalls by certain old sewers in the old days before the catch-pit system was in general operation in London, and, in fact, upon circumstances totally inapplicable to the present day. When you take those two things together, and the third, namely, that he found the maximum amount observed at a particular time of the day, and calculated that it obtained through the whole of the day, I think I may take it that these tables do not show any reliable results. On the other hand, you have given you, both by Mr. Dibdin and by Dr. Dupré, a comparison of the analyses of the present day with those of six years ago, which shows most distinctly that the fact is that any change, though it is very slight, is rather for the better than otherwise.

Now, after what your Lordship has said upon that point, I think I may pass away from the chemical question with great satisfaction to myself, and probably to your Lordship. I will only notice, in passing, the very striking confirmation of our views and of the views of the chemists whom we have called, which is afforded by Dr. Sorby's observations, which have confirmed themselves in one or two ways, but which fit in remarkably with the observations of the chemists, and give and derive additional value to and from them.

Now, the next thing I ought to touch upon is the question of mud deposits. It is charged against us generally, and more particularly with regard to Erith Bight, that the result of the sewers has been to accumulate a large mass of what they hardly dignify with the name of mud, but describe as sewage filth, which is choking up the channel, and rendering the district uninhabitable on land and inaccessible by water. That is one of the most important things the Erith people rely upon, and I hope your Lordship will bear with me when I make a few observations upon that, for it really seems to be an entire misconception of what a mud bank is, and how it is formed. Of course it is obvious to everybody that a mud deposit is formed by matter that was in suspension in the water, which has been carried by the water, and must have been dropped in that place. It must have been in general suspension in the river before, and the reason why it drops at any particular place is that in that particular place the velocity is less, and that it has consequently an opportunity of settlement. That is the history of every sedimentary deposit, whatever it is made of, and in the particular case of Erith Bight, if the velocity in the place where that mud accumulates were greater, it would not deposit, and if it were less, more would deposit. Consequently, to talk of the sewers being the cause of the mud bank is an absurdity. It may be that a portion of the material of the mud bank is sewage. I want to distinguish between the two things: the fact of the bank being there, and what it is made of; I say that to talk of the sewers being the cause of the mud bank is absurd, it is simply dependent upon whether the force of the current containing the matter in suspension is more or less. In each case, in the last inquiry, we showed a diminution of velocity upon the part of the river, because, by certain dredging operations, the tide had been drawn to the other side of the river, and by the diminution of the velocity an absolutely necessary deposit occurred. And you have it proved here that contemporaneously, or just before the commencement and formation of the growth of that bank,—for I do not dispute for a moment that it has been growing, and growing lately,—that contemporaneously with that, I say, there were large dredging operations which have increased the sectional area upon the north side of the river, which consequently encouraged the tide there, and gave there, as you will find by the evidence, an actual eddy in Erith Bight, with the consequence that whatever was in the Thames water in suspension was there allowed to deposit. Now, it is given in Dr. Sorby's Report, and it was proved in the last inquiry, that the usual amount of suspended matter in

Thames water, or anywhere, is about 12 grains per gallon.

(*Chairman.*) Do you mean 12 grains in weight?

(*Mr. Bidder.*) Twelve grains in weight per gallon. Now that which we discharge with the sewage upon the tide, if you divide it by the water, is only one tenth of a grain, and it is divided into 250 times its volume of water, therefore only a very minute proportion of that is of sewage origin. That alone would lead you to the conclusion that where you do get a mud deposit a very small proportion of it would be sewage matter. But there is another fact, and that is this, which, I think, Dr. Sorby refers to in his Report, that the sewage mud is of lighter specific gravity than the general Thames mud. Now of course you would expect the heaviest particles to fall first, and that that which is lightest would probably be found in lesser proportion where you get the mud deposit than the other. Those two things taken together will lead us to expect a very small percentage of mud in any part of the river. Seeing that the percentage of mud in the river is very small, and is light, you would expect a small percentage. When you come to a chemical analysis of the mud, you have some witnesses who said some of it was black, others that it was black filthy stuff, and others that it was reeking, and various opprobrious terms were used, but none of them had analysed it to show that it was sewage. Dr. Tidy had not analysed it to show that it was sewage, he said, on the contrary, that it was very much like all other muds, but I think you have a table before you, showing a large series of muds in all parts of the river, and showing most distinctly that the worst muds are rather inclined to be found at the top of the river than down in these regions; and that is what your Lordship finds when you come to test these muds, particularly if you submit them to microscopical examination. You have had Dr. Tidy, who gives you descriptions of striated muscular tissue and yellow amorphous matter, and other things that he could not exactly recognise, but he detected those in the mud; but he says, very fairly, my method of examination is not quantitative. All I can tell you is that they are there, whether 1 part in 10, or 1 part in 10,000, I cannot say by the method I have adopted. Now Mr. Lionel Beale who had examined also microscopically, and who was called by my learned friends as a witness, went further; he said, "My observation "is that the remains of fœcal matter will not be the "$\frac{1}{1000}$th part of the bulk, something even less than "that, and the rest of it is all made up of sand." And not only did he go further, but Sir John Coode asked him this question, "The sand would not surely "be in the proportion of 999 to 1000?" and he said, "I have not examined it with that view, but I have "been astonished at the small amount of organic "matter in proportion to the amount of mineral "matter." Now this is the "reeking sewage mud" which they have reported upon.

Now, Dr. Sorby, when he examined it, tells you he has gone still more minutely into it, and he makes the fœcal matter in the sewage $\frac{1}{40}$th of a per cent. or 1 part in 4,500, so that there is, I may say, a concord of opinion that those uneducated persons who judged by the eye and gave vent to their feelings in their evidence (somewhat, I think I must say, prone to exaggeration) were entirely wrong when they called this sewage, or described it as anything like sewage.

And another observation of Dr. Tidy's I must call attention to, in which he agrees with our witnesses, namely, as regards the absence of smell in the mud. It is a remarkable thing, but you have many of the other witnesses who come and tell you the same thing. Now, Dr. Tidy was asked at Question No. 10,267, "You have yourself told me that you "were very much struck, in examining the muds "in this part of the river, with the absence of "smell"; to which he replied, "Very often that "is so, but at the same time I do not say I have not "smelt a smell over and over again." I knew it was on the Mud Inquiry that he stated that he had been very much struck with the absence of smell. Now let me remind you that Sir Frederick Abel, who was examined, stated that he put a rod into the mud and stirred it about and brought it up and smelt it. It is a matter upon which you can have very little doubt. When you try it for yourselves and examine it, and see whether it is offensive mud, you will find that it has no smell, excepting, as all muds smell, of mud; still I quite admit that you have had a good deal of evidence of some people residing and working in Erith and its neighbourhood, fastening upon that mud particularly, and telling you of offensive smells and nausea, and that in some cases men have been obliged to go away from their work. Now I do venture to think that all the evidence disproves the sewers as being the cause of it; and inasmuch as there is now made manifest another and a very proximate cause, a very palpable and sufficient cause, in the shockingly bad sanitary arrangements of Erith itself, I do not see why it should be suggested that the metropolitan sewage is connected with it. Because, what do you find admitted? That all along that mud bank there are local outfalls; I think it is four or five. I am not sure of the precise number, but they are described by Mr. Egerton, the surveyor, as sewers which discharge the sewage of a considerable portion of Erith. Dr. Jessell said the greater part of Erith proper was drained into these sewers; a very much smaller amount of course than what we discharge at our outfalls, but it is a question of the manner in which it is discharged. It is not discharged into the body of the river, where it would be fairly distributed, but it is allowed to dribble over the banks; it is allowed to lie festering in the sun; but you will read the description of what was seen by Mr. Chatterton and the others of our witnesses who went down there and found that there was a collection of slaughter-house garbage and other filthy refuse described by them, well calculated to make a most abominable nuisance. Now a couple of men named Harling and Clarke were called, who gave evidence of this kind, that they worked at the Erith Ballast Wharf, and that upon one occasion when they worked they were very ill. I do not know whether they did not say they had to go to the doctor; and there were some cases which Mr. Saunders gave of certain men who worked in the mud at Mr. Beadel's Wharf, their occupation being to clear away the mud which collected on the bank there, so as to keep the barge bed clear, and those men were said frequently to suffer from nausea. They were working within 80 yards according to Mr. Egerton, and according to Mr. Chatterton less than that, from the place where these sewers are pouring out their filth upon the shore. Is not that sufficient to account for the symptoms described? There is another man who is said to have been washing out his boat upon the bank of the river, and was obliged to go away and get some brandy and water at a public-house. Then Dr. Voelcker, you will find, says in answer to Question No. 16,368, "All I can say is that there was an abominable "nuisance arising from the refuse of the slaughter-"houses. The smell was most disgusting. We "counted no less than 14 sewers or sewage pipes "that discharged their contents upon the foreshore. "There were also entrails, bits of skin, and similar "animal matters all scattered about the shore;" and then he was asked, "Was what you saw at "Erith sufficient in your judgment to account "for the complaints of nuisance from the people who "work in the mud and along the foreshore there," and his answer was, "Yes, quite so. The fact is, it "was such an abomination that Sir Frederick Bram-"well who walked with us would not venture to go "very far." When you have palpable and immediate sources of nuisance like that, and on the other hand the fact proved, both by chemical analysis and microscopic evidence, that there is not a trace practically of sewage matter in the composition of the mud bank itself, excepting that which lies in this way festering upon the surface, and which is distinctly Erith

9 July 1883.

sewage, I say it is impossible to come to any other conclusion than that this is a nuisance arising distinctly from local causes, and that the Metropolitan Board of Works sewage has nothing to do with it. It is impossible to attribute what is felt and observed there to the less than the $\frac{1}{10000}$th proportion of organic matter which is formed in the mud of the river itself.

But now Erith seems to be particularly unhappy with regard to its sanitary arrangements, because they seem to be victims of bad smells of all kinds. In the first place, I notice, that Mr. Egerton tells us that they have a large dung wharf at Erith, at which, I do not know whether it is natural or artificial manure, is loaded or unloaded, but which at times has been so offensive that they have actually had to prosecute the lessee; and, in the second place, you have had described to you, and have seen, and probably smelt, the series of factories that there are between the outfalls and Erith,—factories which produce every kind of abomination conceivable on both sides of the river, which, curiously enough, we find from the documents which have been produced and put in, have been the subject of continual reports upon the part of the Erith people themselves, although, until the subject of this present agitation came forward, the sewage itself was never alluded to in their reports. It is a curious thing, on the other hand, to notice that, if it were true that the great nuisance and the bad smells that the Erith people complain of come from the river, it is a particularly favourite place, as we hear, for pleasure yachts; and, if you recollect, Dr. Sorby conducted his experiments there for a couple of months, and lived on the water, and never found anything offensive; that he washed the decks of his yacht with the water; and it is worth while noticing, *en passant*, though it is not of course conclusive, that the health of the inhabitants of Erith is admitted to be exceptionally good, in fact, astonishingly good. Dr. Jessell, the health officer, tells us that in 1880 the death rate was 14½ in 1,000, and in 1881 I think it had fallen to 11 in 1,000; in fact, from my knowledge of death rates, I may say it is almost unprecedented as far as indicating a very high state of health goes.

Another fact I should like to class with that is these training ships; no doubt, there have been one or two occasions in which there have been fevers and outbreaks of various kinds on board of them, but not traceable to the river. On the contrary, one of the worst of them, if I recollect right, turned out to be a case of measled pork or trichinosis, but it is a striking fact that you have a large number of boys living in what actually, according to the other side, is the sewage stream, and that their general health is admitted to be particularly good.

Still I know your Lordship has it in your mind that a large number of people have come and have given evidence with regard to actual smells that they have smelt, and offensive substances which they distinctly trace to the river. I have three observations to make with regard to them. In the first place, I think some of these statements are excessively exaggerated. The large bulk of these witnesses which my learned called were such witnesses (of whom he said he had 200 more) that I have no doubt at all you have only to go to the "Golden Anchor" again, and provide the necessary liquid refreshment which was provided upon that occasion, in order to get evidence, similar or stronger, if necessary. I put it in the first place that their statements are exaggerated and illusory; in the next place, I submit that they did not take pains to discriminate between what was due to the river and what was due to the factories or local abominations. Another observation I make is that the evidence is founded a great deal, in many cases it is distinctly said to be founded upon observations in the immediate neighbourhood of the outfalls. Now, nobody disputes that within a certain distance of the outfalls,—it is usually put at from 200 to 300 yards,—but no doubt, when the wind is blowing that way, you might smell it half a mile, and I have no doubt that the smell which these captains experienced, and which they have described, was a smell in the immediate neighbourhood of the outfalls. Take, for instance, Mr. Sandford,—it is somewhere about No. 600 in the evidence,—he said he had smelt the river between Jenningtree Point and Tripcock Point. Now that, if I do not mistake the map, just comprises the immediate neighbourhood of the outfalls. Practically, Tripcock Point, which is called Margaretness, is just above the Crossness outfall,—between the two outfalls,—Jenningtree Point is a little below between that and Erith.

Now you will find that Mr. Sandford said he smelt the river; that is where he smelt it, between Jenningtree Point and Tripcock Point. Then there is a gentleman of the name of Mr. Savory, a very appropriate name; he says, I smelt it principally in Halfway Reach; and then Mr. Shepherd, another witness, said he smelt it at Crossness. Those are witnesses who located their smell distinctly to the immediate neighbourhood of the outfalls, and it is worth while noticing that Mr. Savory, if you look at Question 1470, says he smells the factories at Erith, but he says he does not smell the Thames.

(*Chairman.*) There was a remarkable thing said by Captain Arthur Gillett, of the "Warspite," at Woolwich. He is asked at Question 811 "At what time of the tide do you notice it worst?" and he said, "At all times of the tide. I do not think it makes any difference." Now that cannot be, you know.

(*Mr. Bidder.*) I am going to make the same observation of a great deal of the evidence. To say it is just the same at all times of the tide is to say that the water which comes down from London Bridge is as bad as that which comes up from the outfalls. Now, Captain Gillett's ship is moored off Woolwich, and if he is near North Woolwich, it only confirms what I have suspected strongly from other evidence, that that is a special and local source of pollution which takes place in the discharge of the East Ham Local Board sewage, just by North Woolwich Pier.

(*Chairman.*) Upon my word, that is rather good; that the London sewage is not a nuisance, but the East Ham sewage is; that was a *lapsus*, was it not?

(*Mr. Bidder.*) No, not at all, my Lord; what I mean is this, that it depends upon how you discharge the sewage. At Erith the amount of sewage discharged is ridiculously small as compared with ours, but if you pour it upon the top of a mudbank, and leave it to ferment in the mud, you may make an intolerable nuisance. Half a dozen privies draining upon a bank of dry mud would probably make a greater nuisance than the sewage of the whole of London when properly put into the body of the river. What I say is that there is a very strong discharge of sewage at North Woolwich, which, as I gather from some of the witnesses, is discharged out upon a bank within a few yards of this spot.

(*Chairman.*) Have we any evidence of the manner in which the East Ham sewage is discharged?

(*Mr. Bidder.*) We have it in evidence that there is a sewer there that discharges through a reservoir, and the reservoir is discharged, I think, at low water. But whilst I am upon that point :. Question 3250 Sergeant Gillam was cross-examined by my learned friend, Mr. Michael; he was asked, "You said some-
"thing about the discharge from the penstocks at
"North Woolwich; is the river very bad when those
"penstocks are opened?" And he replied, "Yes,
"the water is discoloured for some considerable
"distance, and in warm weather it smells very badly.
"(*Q.*) How often does that occur? (*A.*) That I
"could not exactly say. I believe, once in every
"24 hours, but of that I am not positive." Now, if your Lordship will consider it, I am not so beside the mark. I admit, as regards the metropolitan sewage, that where it is discharged there is an offence. I do not pretend there is not, for a moment, and I say there is strong evidence that the same thing takes place at North Woolwich, and that, if

that were taken to our outfall, or discharged in the same manner as our sewage is, there would be no nuisance. Now, I was going to say, if you turned to Mr. Showell's evidence at Question 3421, you would find the same story. He was asked, "You have "spoken of the smell in the river. I understand that "the place which you identify as being that where "you have detected the most distinct and offensive "smell is on the north shore at North Woolwich," "and his reply was 'Yes.' (*Q.*) Was it near the "ferry pier? (*A.*) Close to the pier." I asked that witness if it was near the penstocks, and he said he did not know where it was. Now, at Question 4140 Mr. Naylor was examined by my learned friend Mr. Beaumont Morice, and he was asked in cross-examination, "Do you represent the sewage work at "North Woolwich as being offensive?" And he replied, "Yes, certainly. (*Q.*) And causing con-"siderable smell? (*A.*) Yes. I do not say it is all "caused from that one particular spot where the small "reservoir is, but from the larger one, the northern "outfall." He threw back the responsibility of it upon us, and then he was asked, "You represent that "one as causing a bad smell in the neighbourhood? "(*A.*) Yes. (*Q.*) And a sewage deposit on the "mud? (*A.*) That is so. (*Q.*) That you say from "your own knowledge? (*A.*) From my own know-"ledge. (*Q.*) And to a considerable extent? (*A.*) To "a considerable extent. I have occasion to cross "the water very frequently on business matters. "(*Q.*) By the Woolwich Ferry? (*A.*) Yes. (*Q.*) "That is where you principally notice the smell in "the river? (*A.*) Yes, because sometimes we have "occasion to wait upon the pier for a quarter of an "hour or 20 minutes." And I recollect another witness described the position of the outlets as being close to the pier. I cannot put my hand upon the name of the witness. All that seems to me to indicate that there is a local centre of offence there, just as much as our sewer, I admit, is a local centre of offence just at the point where the discharge takes place. Now, at Question 1470, Mr. Savory, who did not exaggerate so much as some of the other witnesses did, and who was examining officer of the Custom House officers at North Woolwich, was asked, "Have "you ever experienced any offensive smell from any "of the factories on either side of the river there?" And his reply was, "I have done so from the atmo-"sphere, but it did not appear to me to be from "the water. You can tell generally whether a smell "comes up from the water or whether it blows over "your head. For instance, we get that smell in our "houses at Erith; we do not get the smell of the "Thames. All these smells from the factories we "are favoured with in our dwelling-houses." Now, the question was asked, I think by your Lordship, whether anybody could be produced from Erith to say it did not smell. Now here is a witness produced from Erith who says most distinctly I have got the smell of the factories, but I never got the smell of the Thames at Erith in my house. Now what can you say, but that there is the grossest exaggeration on the part of a body of witnesses like Mr. McAlister, a clergyman of Plumstead, who smells it four or five miles inland, and that, when there is an east wind, it depresses his vital force. Now, it is not the first time that I have heard of the east wind depressing a man's vital force, and it is not necessary to pray in aid of the sewers of the Metropolitan Board of Works for that purpose.

Now, there are the fishermen. There come these fishermen and say, at least some of them do, that the proof of the pollution is that a number of little red worms used to be found in the river, but now we never find that there are any. But then you will observe that there comes another squad of fishermen to say that the proof of the pollution is that, whereas there never used to be any worms in the mud of the river, now it is swarming with them. This discrepancy is so noteworthy that my learned friend Mr. Bazalgette has kindly made me out a list of them on each side, and I find there are seven who prove the disappearance of the red worms, and four who speak to the presence of the worms.

Then there was another remarkable thing which we may recall; there was one witness who proved the existence of a new species of worm which fed on rope, but nothing else; he said they used to eat his ropes, and they were no use for bait, for nothing would eat them. Then there was another witness, Mr. Gatward, who said he smelt the sewage at Gravesend. I do not hesitate to characterise that as a gross exaggeration. There is another who said he smelt it all the year round. Now, when your Lordship and the Commission have been there, did you smell it; was there anything to smell? My learned friend says it was a cool day; all I can say is, if you have not been satisfied with that smell, go again and smell it for yourselves. If you go near enough to the outfall when the sewage is coming out, you will smell something very nasty, but if you get a reasonable distance further off, I venture to say you will confirm the evidence of all our witnesses, and mind you have a large number of them. You have Dr. Coleman, who resides at Woolwich, and he said he had never smelt the river until his attention had been drawn to the matter by this inquiry, since when he had smelt it once or twice. There was Dr. Rowarth, of the "Exmouth," who said he had never observed the smell. There was Dr. Wise, of Purfleet, who said he did not smell it. There was Captain Miller, of the "Castalia," who lives in it at Erith and bathes in it every morning, and there was Sir Frederick Abel; I should like to remind you of his evidence; it was not very long.

(*Chairman.*) That at 1,000 yards, I think he said, you might smell it when you were upon the river, but that after that, if you took it up and shook it in a bottle, you might still get the smell.

(*Mr. Bidder.*) Yes, but your Lordship will remember that persons travelling up and down the river are not bound to take it up and shake it in a bottle; if they do, they have themselves to thank for all they smell. Now he has lived at Woolwich for 30 years, not upon the North Woolwich side, but upon the south side, by the arsenal. At Question 16,271 he says that he has lived at Woolwich for the last 28 years, and that his house is within 250 yards of the river, and that his place of work is within 180 yards of the river; and then he is asked at Question 16,273, "Have you experienced any annoy-ance from the river," and his answer was, "I have "not. I may state that a walk upon the river wall, "and a breath of fresh air upon the T-pier at the "arsenal in the evening, has very often been my only "chance of getting anything like recreation and "fresh air; and I have never upon any occasion "experienced the least annoyance or inconvenience "from the river at that point;" and then my learned friend Mr. Bazalgette says, "You have given "your own experience. Now, of course, there are "many others employed at the arsenal amongst "whom you constantly move"; and his reply was, "I am surrounded by a small number of houses "occupied by official residents, with whom I am "more or less intimate, and I may state that we have "had during these 28 years the usual visitations of "sickness of one kind or another, but certainly in no "one instance has there been any case of sickness "which could be ascribed even remotely to the "outfalls. I say this not simply from my own "personal opinion, or as my own personal view, "but that is the view of medical men living in the "same place and attending upon the families." Then he says, "We are great sufferers from smells, "not only in the arsenal, but high up on Woolwich "Common, the smells extending as far as Blackheath, "all of which come from the large and increasing "number of factories surrounding the outfalls and "situated about the outfalls, and to a considerable "extent up the river as far as the Victoria Docks. I "believe there are as many as 14 manure works of

9 July 1883.

" one kind or other, large and small, and some of " them of the most offensive description." Now I cannot conceive a man more competent to judge of that than he is. Now, perhaps, I may read this further answer, because it has a bearing upon what he was cross-examined about. He was asked at Question 16,301, "Now, with regard to Woolwich " itself, is it not the fact that complaints have been " made by residents as to the sewage?" And his reply was, "Not to my own knowledge. I believe " that upon several occasions complaints have been " made of smells which, not unnaturally, have been " ascribed to sewage, because they have been due to " offensive odours something like, though much more " intolerable than, the odours evolved from sewage. I " refer especially to the odours coming from the fish " manure works, which are so disgusting that I trust " the Commission may have the chance of experienc- " ing them for a moment. I am not at all surprised " that they have been ascribed to emanations from " excreta, for I am convinced that in many instances, " and certainly at Woolwich, smells of this descrip- " tion have been mistaken for smells emanating from " the sewage outfalls. (*Q.*) However, you agree " with many of the witnesses that you can dis- " tinguish between the sewage outfalls and the " factory smells? (*A.*) The educated nose can; the " popular nose, when it is in the neighbourhood of " the sewage, would say, that is a sewage smell, when " it smells any smell."

My Lord, I cannot help thinking that that accounts for a great deal of the evidence which has been brought here; the neighbourhood abounds in smells, and that is the very reason why the outfalls were put down into that neighbourhood; but, taking Sir Frederick Abel's evidence, it seems entirely to negative any smell being traceable to the river when he lived there. If you think Sir Frederick Abel is right as regards Woolwich, then what am I to say as regards Greenwich, which is higher up? It is impossible the smell can skip Woolwich, and then reappear higher up at Greenwich from the outfalls. But there are smells traceable at Greenwich, and one gentleman said that when he went across the river he was always sick. I confess I cannot understand it. I suppose it is the same place at which one always lands when one goes on a summer evening to enjoy a fish dinner, and one must not quote one's own experience, but I might say I have never experienced it myself.

Now I will draw attention to this. Captain Gillett stated, not only that there was a smell, but that there were slate-coloured patches which came to the surface and floated up and down the river, more especially in the summer time.

(*Chairman.*) You are referring to No. 828.

(*Mr. Bidder.*) Yes, he says it came up in great masses of black stuff, sometimes as big as this room. Now there is another gentleman of the name of Lewis who, at Question No. 5020, also spoke to that, but he added another fact about it, which seemed to indicate that it was not the result of the outfall. He describes this matter floating about in black patches; " it seemed like floating mud, as it were, in black " stinking matter. As soon as you touched it, it " tumbled to pieces." And at Question 5018 he says that in the year 1880 "the river was very black " indeed during the summer, say, from Jenningtree " Point right up pretty well to the Cherry Garden " Pier."

(*Chairman.*) That is at Rotherhithe, is it not?

(*Mr. Bidder.*) Yes, at Rotherhithe. Then my learned friend Mr. Lumley Smith asked him this question, "Had that occurred before within your knowledge?" He had said that this occurred in July 1880, and he says that it had occurred in 1858.

(*Chairman.*) The water which was coming from the outfall might find its way up to Cherry Garden Pier, but according to the evidence that would be deodorized and destroyed.

(*Mr. Bidder.*) One must not say that it would not find its way, because according to the analysis some of the salt water comes up there; still Cherry Garden Pier is a good many miles from the outfall, and if any went up there it should be a very small proportion.

(*Chairman.*) One way in which it might be carried up would be by the mixing action.

(*Mr. Bidder.*) Yes, but what I want to show you is that the same phenomena happened in 1858; now that is before the outfalls, which were not opened until 1865. If you look at Question 5029 in the evidence of Mr. Lewis, who is the port sanitary inspector——

(*Mr. Webster.*) You will find he says it was much worse then.

(*Mr. Bidder.*) Be it so; but then at 5023 you will find he says that the patches might be about the size of the table, floating up and down; and then at the bottom of the page, when he is asked whether it had occurred before, he says it occurred in 1858; and then he is asked at Question No. 5032, "In 1858 " do you remember anything similar to what you " saw in 1880?" And his answer is, "There was a " greater amount, and it lasted a longer time."

(*Mr. Webster.*) He denies its being in patches, in answer to Question No. 5039.

(*Mr. Bidder.*) He says the same thing occurred.

(*Mr. Webster.*) That is your view of the "same thing."

(*Chairman.*) He says in 1858 it was a full black ditch. I do not quite understand that.

(*Mr. Bidder.*) Why I refer to that is for this reason: if he is right, it shows that that was produced by causes certainly other than the outfalls, or at all events might be produced. I do not say it entirely excludes the outfalls, but it is an extremely unlikely thing that up as high as Cherry Garden Pier you should have a concentration of filth produced from these outfalls in that way. And again, I have to remind you that there are a number of other sources of pollution distinctly identified as occurring in that very part of the river. The North Woolwich sewer I have spoken of—the West Ham sewer draining into the Lea, draining 120,000 persons, besides all that floating population of something like 20,000; and, connected with that fact, we have shown you by the evidence of Dr. Tidy that it is the matter in suspension that makes patches, not the matter in solution; and that as regards the matter in suspension that part of the river in the neighbourhood of London Bridge, and down as far as Deptford, is twice as bad as that in the neighbourhood of the outfalls. Now, patches must be made up of matter in suspension and of organic matter, and, seeing that you have twice as much of that in the upper part as in the lower part, it appears to me that you have a very adequate cause of these patches and this apparent pollution.

Now my learned friend Mr. Bazalgette reminds me, though it is probably in your mind, of a minor point in connexion with the mud. There has been a good deal said about its blackness as indicating its filthy character. Now Sir Frederick Abel has explained that, and he says that, in point of fact, the blackness is not any indication of putrescence, but that, in point of fact, it is caused by sulphide of iron. In answer to Question No. 16,244, he says, "If, by the putrefactive " decomposition of the nitrogenous organic matter " suspended in water, sulphuretted hydrogen be " evolved, this iron compound will fix the sulphur " from the sulphuretted hydrogen and will act " equally upon the other sulphur compounds, pro- " ducing sulphide of iron, which sulphide of iron " gives that black appearance to the mud, conveying " to the uneducated mind a notion of filth and im- " purity which is erroneous, inasmuch as it is an " indication of the purifying action of the mud " itself."

Now there are only one or two minor points which, it strikes me, are worthy of notice in that evidence produced by my learned friend Mr. Beaumont Morice. You have a great deal of evidence about the fish—

you know exactly what our view is about the fish question; there is not the slightest doubt about it, there has been a great disappearance of fish there, I believe, owing to the disappearance of the oxygen in burning up the sewage—the same thing as Dr. Tidy in his pamphlet pointed out was the inevitable consequence of putting sewage into a river and using up the oxygen.

Then there is only one other thing to which I will call your attention, viz., that Captain Miller of the "Castalia" was in Galleons Reach for a long time, and he declared he never smelt the smell there. And it is singular that that is between Woolwich and other places, so that you smell the smell at Woolwich, and you can smell the smell at the outlet, and you do not smell the smell at midway, which seems to confirm our evidence.

(*Chairman.*) Now what do you say to Captain Burstall; he is a witness of unimpeachable veracity, and, as it struck me, of very great sagacity; he is the captain of the Thames Conservancy boat.

(*Mr. Webster.*) And he has been so for 40 years.

(*Mr. Bidder.*) I have the greatest respect for Captain Burstall, but I confess I think his nerves have got the better of him. No doubt, he has smelt it near the outfalls, but I think his recollection or his imagination have carried the smell further than it extends. There is no question that anybody may go to-morrow or to-day and smell a filthy smell if they go near enough to the outfalls, and if the wind happens to be blowing in their direction it may go a little farther, but it only comes to this, if you are perplexed between two bodies of witnesses, why not go down again and satisfy yourselves, it is not like something that has happened and is past and cannot happen again.

(*Chairman.*) I think we have said that, if there never was any greater nuisance than we found when we went down there, it would not be worth mentioning, and I rather think Mr. Beadel, Mr. Beaumont Morice's client, said the same thing.

(*Mr. Beaumont Morice.*) It was a very cool day when you went down.

(*Chairman.*) It was a cool day and very high water, and plenty of fresh water over Teddington Weir, everything in the Board's favour.

(*Mr. Bidder.*) I am told now it begins to smell at 65 degrees, and that the temperature of the river water is now 68, so that you ought to find it smelling abominably.

(*Sir John Coode.*) I think you may safely leave that to the Commission.

(*Mr. Bidder.*) I say, wait until the warmest day you can find, and go down then and see whether you can find anything more than what I have admitted from first to last as being the immediate local effect. And, as I say, you cannot get rid of that; put the sewage where you will, you cannot find up and down the Thames a better place to put it; but as regards the general effect of the evidence, I venture to think the evidence upon the subject is all either exaggeration or misconception or want of discrimination between one source and another, or mistake as to what the source is altogether.

I am reminded that one consequence, if you were to put the sewage below Gravesend, would be that you would have no fish in the Thames at all. They are happy now that the sewage is put in where it is, but if you moved it below Gravesend, they would not come up the river at all.

Now I am very much obliged to your Lordship and the Commission for listening to me with such attention and patience in such a very dreary business. I do not think I have any further observations to make upon it. I think you had better trust to your own noses and eyes. Even if my learned friend Mr. Beaumont Morice is permitted to call up a second batch of witnesses, I have no doubt he can do so with perfect ease, but I think that neither your time nor ours will be profitably occupied in rehearsing that business again.

(*Chairman to Mr. Beaumont Morice.*) We do not know that we shall avail ourselves of any of the army of witnesses you are ready to call, but we really think you ought to give a copy of the names to the other side.

(*Mr. Webster.*) Of the names?

(*Chairman.*) I think I should say, of their statements, in candour and fairness.

(*Mr. Webster.*) I think my learned friend Mr. Beaumont Morice will be perfectly willing to do so, but a number of them are persons of superior position who expressed a wish not to be badgered by counsel, and perhaps their proofs have not been taken.

(*Chairman.*) I do not mean, of their proofs, but a list such as we have before us, because, even though we do not call any of them, we may be impressed by the number. And possibly (*to Mr. Bidder*) you might give us a list of another 500 upon your side.

(*Mr. Bidder.*) Sir Benson Maxwell gave us a pledge that we should have the same privilege reserved to us.

(*Mr. Webster.*) I shall be able to point out to you what the Board of Works have been able to do in the way of getting up witnesses. I think your Lordship has mentioned, incidentally, Captain Miller, who, except the medical officer, is about the only independent witness that the Board were able to get.

(*Chairman to Mr. Webster.*) We will not want you to commence to-day.

(*Mr. Beaumont Morice.*) I shall want to say something, considering it was in consequence of my memorialists' representation that this distinguished Commission has been appointed, and seeing that my learned friend Mr. Bidder has made a direct attack upon the drainage of Erith.

(*Chairman.*) But the Erith case and Mr. Webster's case are the same.

(*Mr. Beaumont Morice.*) But I have brought forward special evidence with regard to Erith.

(*Mr. Webster.*) If you begin at 12.30 on Wednesday, then I will undertake that my learned friend Mr. Beaumont Morice shall have an hour out of the day. I shall not occupy the whole day. But there is a table I wish to hand in with regard to the statement that it did not rain at the same time at Greenwich and Kew; the discrepancy arose from the fact of their having only taken over ·25 of an inch of rain in 24 hours.

(*Mr. Bidder.*) Does it always appear to rain at Greenwich when it does at Kew?

(*Mr. Webster.*) In this particular table it does.

*The document was handed in. See Appendix C.E.*

(*Mr. Bidder.*) As regards this further evidence, you will exercise your own discretion.

(*Chairman.*) We will consider it.

Adjourned to Wednesday next at half-past 12 o'clock.

# FORTY-SIXTH DAY.

## Wednesday, 11th July 1883.

PRESENT:

THE RIGHT HON. LORD BRAMWELL, F.R.S., IN THE CHAIR.

SIR JOHN COODE, Mem. Inst. C.E.
COLONEL C. B. EWART, C.B., R.E.
PROFESSOR WILLIAMSON, F.R.S.
FRANÇOIS DE CHAUMONT, Esq., M.D., F.R.S.
THOMAS STEVENSON, Esq., M.D.
WILLIAM POLE, Esq., F.R.S., *Secretary.*

11 July 1883.

(*Mr. Webster.*) My Lord, I have now to endeavour to make a few observations to your Lordship and the Commission upon this matter which is before you; and may I be allowed to make one preliminary observation, and to ask for your Lordship's indulgence; and more particularly for the indulgence of what I may call the scientific members of the Commission. I am vain enough to hope that in the old days upon matters of law I may have been of assistance to your Lordship, and in some scientific cases I might hope to be of some assistance even to scientific gentlemen, but this is not a case in which I could venture to hope to be of assistance to the scientific members of this Commission. Any observations I may have to make upon scientific points will be supplied to me by others, and I trust you will forgive me if I do not always use correct expressions upon the scientific points.

My Lord, I do not propose to attempt to argue the scientific question out at length; I think at the present stage of the inquiry it will not be my duty to do so, because I have to call your attention, I think, mainly to the question of whether there has been,—(I will not say a nuisance) but anything calling for substantial complaint. But I shall, incidentally, in connexion with that question, call attention to three or four leading scientific points for the purpose of seeing how far, when the Commission come to consider the evidence before them, the scientific evidence given bears upon the existence of anything which has been complained of, whether it is called a nuisance or not. I propose to comment very briefly in the course of my own observations to your Lordship and the Commission upon what my learned friend Mr. Bidder has said, and not to endeavour to deal seriatim with the points he has taken. What I propose to do is, first, to call your attention to the scientific matters upon which I ask the attention of the Commission, and then to ask attention to the matters of fact with which I feel more competent to deal, and which I think are of the greatest importance. I will ask you to notice one matter which was mentioned by my learned friend Mr. Bidder incidentally. It is quite true that the Commission at present have not gone into the question of any remedy or alternative scheme, or anything of that kind, but my learned friend Mr. Bidder, as part of his argument, indicated to your Lordship that any change must mean the change of going further down the river with the outfalls. Now, on behalf of the Corporation of the City of London, I ask the Commission distinctly to understand that at present they have expressed no such opinion, nor, so far as the evidence has gone, is there any ground for believing that they would ever suggest any such opinion if they were asked to assist. But what I am going to call your attention to as the principal fundamental cause of nuisance, if nuisance does exist, or is growing, is the turning out of solid matter into the river at this particular point. I have no intention of discussing before your Lordship whether the point is a right or a wrong point, but, assuming the point to be right, what I desire to say in answer to my learned friend Mr. Bidder's suggestion is, that we do not at all approach it from the same point of view. In the judgment of those who advise me, other questions would have to be considered, of as great or of greater importance, as to how far it would be right to send out the sewage bodily with its solids into the Thames at all. I may refer to the line of thought which has run through the deliberations of the Rivers Pollution Commission, which has been, as your Lordship and the other members of the Commission know, towards improving the effluent water which was sent out, as distinguished from sending it out in a whole stream. I mention that, because we wish it to be understood that the question is not only where the sewage should be sent out, but that there are other questions both of circumstance and degree, as to the way in which this question should be dealt with.

Now I want to make two or three criticisms as to the way in which this case has been dealt with scientifically; and they are rather in the nature of criticisms upon matters of principle, which I think the Commission will have to consider carefully if they deal at all with the scientific part of the case; and the first criticism is one which I venture to make upon the views presented by the two bodies as to the amount of solid matter which there is in sewage. Now I can very shortly put this before the Commission, and they will see why it is of importance when they come to examine the evidence for themselves. Dr. Tidy and Dr. Frankland consider about 50 grains a gallon is the average quantity. Dr. Duprè on behalf of the Metropolitan Board of Works, takes 25 grains as the average quantity; Mr. Dibdin says 27·39 grains is the average quantity of the suspended matter. Now, I ask the Commission to pause before they would adopt as the basis of any conclusions they may draw, or any recommendations they may make at the suggestion, that either 25 or 27 grains is anything like the right quantity. It is admitted that in every one of their analyses they have excluded all sewage, all effluent from the sewers coming down when there is anything like storm water, or anything like an excess of quantity, and I submit to the Commission that, upon their own tables and their own evidence, a large amount of solid polluting matter comes down in suspension at periods when the sewers are surcharged. I am not dealing with the storm overflows up the river, but I am dealing with sewage brought down which has in it more than the ordinary house sewage. I am dealing with the effect of a sudden storm of rain flushing the sewers out, and bringing down a large amount of road detritus and things of that kind. Dr. Tidy points to this, which I think should be brought to the notice of the Commission. Your Lordship may remember that Dr. Frankland himself found that Messrs. Hoffman and Witt recorded 103 grains per gallon. Dr. Frankland and Dr. Tidy found 119 grains, that is at Question No. 6256 of the evidence upon the Mud Inquiry, which my learned friend, Mr. Bidder, referred to. Mr. Keates, for the Metropolitan Board of Works, in the same inquiry found 95 grains per gallon, that is at Question 9980 of the same evidence; but it appears, I think, more strongly than ever when I give your Lordship and

the Commission the result of the present analyses. The Board have taken 229 samples; out of those there is only one sample, No. 177, which contains above 60 grains. There are only six between 56 and 60; the numbers are 92, 212, 303, 175, 106, and 114, and there are 21 samples containing between 40 and 50 grains; and the chemists who were examined for the Metropolitan Board of Works have stated that they have arrived at the conclusion of 25 grains, and 27·39 grains; and they have expressly said at Question No. 11,058 that whenever they have given details of suspended matter they have invariably omitted all samples taken during the time of storm. Now, we do consider that, as the matter has been put pointedly before the Commission, it might be a very misleading guide in the future, having regard to the experience of this Commission—as any incidental finding of theirs must have a very large effect upon anything which comes afterwards—we consider, I say, that it would be very dangerous if so low a standard were adopted as that of the Metropolitan Board of Works.

(*Chairman.*) Do you consider there is more matter in suspension at the time of the storm overflows?

(*Mr. Webster.*) Yes, we do, and more polluting matter.

(*Chairman.*) Have your people made their calculations upon the basis of taking the storm water?

(*Mr. Webster.*) They have included it.

(*Chairman.*) How do you account for the greater quantity of matter in suspension?

(*Mr. Webster.*) Because, in the first place, a scouring of the small drains takes place, that which sticks to the sides is brought down. In the next place, the heavier particles are removed by the greater flush of water; and, in the third place, the road, which will only dry up a lesser quantity of rain, is flushed and swept by the larger quantity of rain.

(*Chairman.*) The polluting particles are those that stick to the sides.

(*Mr. Webster.*) Those are among them, and upon this point I am only quoting the evidence of Mr. Keates, who has died since he gave his evidence. I find, in several samples, he took the storm water; that is stated at 9980 in the Mud Inquiry. I refer to that for this simple reason, that it is in accordance with experience which has been derived by numbers of chemists, both in England and abroad.

(*Mr. Norman Bazalgette.*) Pardon me for interrupting you, but you gave the Commission a reference to No. 11,058, to the effect that Mr. Keates carefully suspended his inquiry during flood times.

(*Mr. Webster.*) No, I gave the reference to the Mud Inquiry as 9980, which was on the storm outfalls.

(*Chairman.*) You did give a reference to Question 11,058.

(*Mr. Webster.*) That is in this inquiry.

(*Mr. Norman Bazalgette.*) It was Dr. Frankland who said that Mr. Keates carefully suspended his sampling.

(*Mr. Webster.*) Any correction as to matter of fact I shall be very delighted to have. I am only too anxious not to misrepresent anything, but I undertake to verify every reference.

(*Chairman to Mr. Bazalgette.*) What is your objection?

(*Mr. Norman Bazalgette.*) That 11,058 is the evidence given by one of my learned friend's own witnesses, who says that Mr. Keates suspended his sampling during flood time; it is not our evidence at all.

(*Mr. Webster.*) I will quote every answer I have given. I state that in 11,058 there is the statement made that the analyses were made from samples from which flood quantities were excluded, and I have quoted the answer to 9980 upon the Mud Inquiry, in which Mr. Keates then found 95 grains in the storm water, when it was subject to storm excess. I have also quoted the answer to Question 6256, in which Dr. Frankland and Dr. Tidy found 119 grains in the sample of water, and I have mentioned Messrs. Hoffman and Witt, who recorded 163. I am glad to be corrected upon a question of fact, but not upon an argumentative question.

(*Mr. Norman Bazalgette.*) You said that Dr. Frankland and Dr. Tidy gave 50 grains as the suspended matter per gallon. Dr. Frankland's evidence is from 23 to 25 grains, and he says, in times of storm, that is raised to 44 and 45.

(*Mr. Webster.*) I repeat again that the Commission shall judge when they come to consider the whole of the evidence.

(*Chairman.*) It would be better to set this right at once.

(*Mr. Norman Bazalgette.*) I refer your Lordship to Question 10,344, and after that to Question 10,346, it is Dr. Tidy cross-examined by my learned friend Mr. Bidder.

(*Mr. Webster.*) Dr. Tidy is asked at 10,346, "Now "I understand you to say that the increase during "the time of heavy rain and storm in your judgment "raises that, of course we know it must raise it, but "raises it until it is equal to 44 or 45 grains; what is "your ground for that statement?" To which he replied, "My first ground for that is the experiment "of Dr. Frankland. In the Report of the Rivers "Pollution Commission, page 29, Dr. Frankland gives "a series of analyses, and although I am quite aware "that you may take objection to one or two of the "high numbers, nevertheless it gives an average of "between 45 and 50 grains. Then, secondly, during "a storm our own experiments gave some very high "numbers, which numbers in the main (there was a "little discrepancy, owing, no doubt, to the different "times in which we obtained the sample, or the "different condition in which we obtained the sample) "were agreed to by Mr. Keates. And I would just "say that Dr. Frankland and myself, upon the 30th "of December, if you look at the answer to Question "No. 6227 upon the Mud Inquiry, found 119 grains "of suspended matter in a gallon, whilst Mr. Keates "admitted that he found even 95 grains." Now I am in the recollection of the Commission; have I misrepresented one word? The statement is distinct. My learned friend, Mr. Bidder, was cross-examining Dr. Tidy upon the statement of Dr. Frankland, and the point of his question was that it assumed that it was raised to a standard of 44 or 45 grains; and Dr. Tidy gives as part of his reason the fact I have brought to your notice.

(*Chairman.*) Dr. Tidy says, at No. 10,349, "But "the point I am trying to make clear at the moment "is that, though I admit 25 grains to be the normal "amount of suspended matter in a gallon, yet the "time when we get storm sewage is when we bring "up the average enormously," what does "enormously" mean?

(*Mr. Webster.*) It is explained in answer to Question 10,346, it is taken at 50.

(*Chairman.*) Does anybody say what the proportion of pollution is?

(*Mr. Webster.*) Not in this part of the evidence, but I will come to that directly. I am dealing with the solid matter for the moment. Now I mentioned, when the interruption took place——

(*Chairman.*) You must not blame Mr. Bazalgette for it. Even if he turns out to be wrong, he only undergoes the fate which we all undergo more or less.

(*Mr. Webster.*) But I will say here that every reference is given on my notes, and my learned friend shall see them if he likes, and write to the Commission, and point out any mistakes that I have made as to matters of fact afterwards.

(*Chairman.*) This is a most mysterious thing; one cannot fail to perceive that there may be an accumulation, that the first storm water brings it down, and the percentage is very considerably added to; but what if there is a storm every day for a month?

(*Mr. Webster.*) What I desire to bring to your notice is that to exclude all storm water samples, as Mr. Dibdin and Dr. Dupré have done in this case,

11 July 1883.

cannot be an accurate mode of proceeding. Now I will endeavour to supplement what I have to say, by saying that the Rivers Pollution Commission took as the average 48·5 grains of suspended matter in the London sewage, and the report of Mr. Keats to the Metropolitan Board of Works upon the working of the A, B, C experiment gave 57 grains; that you will find stated distinctly in Mr. Baldwin Latham's evidence in answer to Question No. 4734. I have brought before your Lordship sufficient to ask your Lordship and the scientific members of the Commission to pause before they adopt anything so low as 25 or 27 for the purpose of their consideration afterwards.

Now your Lordship asked me whether I could tell how many of those grains were actually polluting matter. I cannot do it in that way, but I am now about to address myself to that which is the next head about which I wish to say a word, and that is with regard to the polluting matter. I will ask your Lordship and the Commission to remember that at Question 9912 Dr. Tidy estimates it at 400 tons a day, and he referred to Röder and Eickhorn as having given valuable statistics with regard to the solid matter in ounces in fæces given as for a certain population; your Lordship will find statements with regard to that at Questions 9904 and 9909. Now I ask your Lordship and the Commission to observe that, although Dr. Tidy gave that evidence very early in the inquiry at Question 9912, we have nowhere had given to us, as far as I know, any estimate of the actual quantity of solid polluting matter sent into the Thames as against the 400 tons a day. I am aware that the 400 tons has been criticised, but we have had no alternative calculation; and I ought also to mention that the 400 tons do not include polluting matter from slaughter-houses, or cow-houses, or filth which might become noxious from kitchens, or laundries, or things of that kind; but it was entirely based upon sewage.

Now I know that Mr. Sorby did not go the full length to which I suggested that Dr. Tidy went; but I ask your Lordship to observe what the results of Mr. Sorby's analyses are, as given in his evidence commencing at page 23, where, in strong average sewage, he says, there are 1 per cent. of fæces, and of the solid residuals four times that amount, and you will also find a number of the results of examinations of samples in Mr. Sorby's microscopic examination, showing that there is a very large proportion of polluting matter in sewage which is not placed there, or does not get there simply by the human fæces, but gets there from some other source, partly from animals, and partly from other polluting things which take place, whether it be trades, or other things, which go on in houses, and which produce pollution.

Now I say again that nobody has pointed out the error which Dr. Tidy is supposed to have made, and nobody has put in upon the part of the Board an estimation of the actual quantities.

(*Mr. Norman Bazalgette.*) Would you kindly look at Questions 16,007 and 16,008, where Dr. Duprè puts it at 100 tons per annum? At Question 16,008 Dr. Duprè was asked, "There was some question of "that when Professor Way was here. I do not know "whether you greatly differ from him, but what "would be the amount of oxygen that you would "require to oxidise that?" and his answer was, "I "should say it is certainly less than 200 tons; we "get therefore only 100 tons a day against the "'400 tons of filth,' which Dr. Tidy calculated as "being discharged into the river."

(*Mr. Webster.*) I think that if my learned friend had observed more carefully he would have noticed that that is a reasoning back and not an argument based upon the actual production of sewage. I am aware of that, and I repeat that though it is criticised, and although the statement is made, yet there is no calculation which approaches the question in the same way as Dr. Tidy's does; nor is an error in Dr. Tidy's calculation pointed out anywhere. It is suggested to me, and I think it is properly suggested to me, that there is no calculation produced bringing out 100 tons, or anything like it; but I am aware that working back from the oxygen process a smaller quantity is mentioned. Sir John Coode says at Question 16,007, "I want to know at what particular "point the samples were taken which you say were "taken from the sewers." And Dr. Duprè's reply was, "They were taken either out of the main reser- "voir or out of the sewer which is discharging into "the river, so that the total amount of organic matter "out of the 1·68 ounces which actually goes into the "river and pollutes the river is only ·056 of an ounce "per head. From the one ounce of fæces about ·14 of "an ounce is also mineral matter, and I estimate that "the total amount of organic matter per head of "population which actually goes to pollute the river "is only ·916 of an ounce per head, which, taking "4,000,000 of people, comes to about 100 tons a day, "or 36,500 tons a year." I desire to say in connexion with this, that if the quantity of solids—polluting solids—be so much less (I at once say I do not accept, and those who advise me do not accept, Dr. Duprè's statement); but if it is so much less, so much easier would be the labour of anybody who had to consider how this amount of polluting matter had to be dealt with. We represent that it is greater; but still if it be so much less, as is pointed out, it would have a very great bearing upon the question which you will at some time or other have to consider as to the disposal of the sewage.

(*Mr. Bazalgette.*) If you will refer to Question 10,437 you will see that Dr. Tidy in cross-examination himself qualifies his 400 tons a day.

(*Mr. Webster.*) It is not a qualification of the estimate, but it is a suggestion that the calculation might be arranged in a different way; and if your Lordship will look at 10,433, Dr. Tidy says, "There- "fore, as far as that is concerned, if you like to take "it in that way, instead of putting it as 440 tons of "moist fæces, it is about 385 tons;" and although my learned friend Mr. Bazalgette says in one sense he qualifies it—he qualifies it upon the assumption put to him by my learned friend Mr. Bidder, upon some difference between German pounds and English pounds.

Now I pass from that, having, I trust and believe, made my meaning clear to the Commission, to the question of analysis, and I ask the scientific members of the Commission to observe the way in which this has been dealt with by the witnesses who have been called on behalf of the Metropolitan Works. Now, my Lord, there is a well-known process, the combustion process, which gives not only the relative, but I believe I state it correctly, the actual result as far as organic carbon and organic nitrogen are concerned. Dr. Tidy followed it, and so did Dr. Frankland—both of them. Dr. Odling admitted that it did give correct results; whether or not anything else might be afterwards determined is another thing, or whether or not, in addition to that, there might not have been room for supplemental experiment. But what I put as the fore front of our criticism upon the Metropolitan Board of Works dealing with this question by means either of the oxygen test or the albuminoid ammonia test is, that they have had under their hands that which would be for many purposes a much surer guide, at any rate, to check what they were doing, and they have not adopted it; and then I am justified, I think, in saying that if they have tried it, the results either do not conform to what they have found, or if they have not tried it, it was because possibly they said they thought their own process was better, or that the results would not agree.

Now, my Lord, ought they to have tried it? If the results shown by their processes have been consistent; if the results of their processes have really shown the same result, subject of course to little discrepancies, I agree that it would have been a strong argument in favour of the view that the albuminoid ammonia process and the oxygen process, though they

might not be actual positive tests of a particular sample of water, might be tests of relative purity. Take Teddington, for instance; if you analysed a sample of water by the albuminoid ammonia and the oxygen tests, Dr. Wanklin's method, and the other one,—and you found a certain standard; and you then took a water which you had every reason to expect to be worse than that, and you found it did come out worse by both tests—that to a certain extent would be taken to be a confirmation that the tests were reliable. It is, however, altogether the contrary. I hand in as part of my speech, and I ask you to allow it to be printed, a table showing, as far as they can be compared, the oxygen and the albuminoid ammonia tests taken by the Metropolitan Board of Works, and the results of Mr. Sorby's microscopic examinations. In every case the page is put, and the number of the sample; and I will ask you to consider what it shows.

*The Table was handed in, and was as follows:—*

*Put in by Mr. Webster, 11th July* 1883.

COMPARATIVE ANALYSIS of THAMES WATER as per EVIDENCE of METROPOLITAN BOARD.

The *italic* figures in the first and second columns refer to the pages in the Table of Analysis made by Sir F. Abel, W. J. Dibdin, Dr. Dupré, Professor Odling, and Dr. Voelcker; and in the third and fourth columns to the page in the report of microscopical investigation.

| Name of Place. | Oxygen absorbed. | Albuminoid Ammonia. Grains per Gallon. | Microscopic. Grains per Gallon. | |
|---|---|---|---|---|
| | | | Fæces, page 23, Sorby. | Excrements, page 23, Sorby. |
| | Page | Page | Page | Page |
| At mouth of the Mole | *25* ·140 | — | — | — |
| Teddington Weir | *25* ·161 | *50* ·0136 | *23* ·0013 | *23* ·0025 |
| No. 254 | *25* ·100 | *50* ·0132 | — | — |
| „ 291 | *25* ·086 | *50* ·0140 | — | — |
| „ 455 | *25* ·208 | *50* ·0203 | — | — |
| „ 463 | *25* ·325 | *50* ·0269 | — | — |
| „ 476 | *25* ·249 | *50* ·0128 | — | — |
| „ 481 | *25* ·280 | *50* ·0171 | — | — |
| „ 489 | *25* ·176 | *50* ·0090 | — | — |
| „ 110 | *25* ·126 | *50* ·0088 | — | — |
| „ 111 | *25* ·109 | *50* ·0105 | — | — |
| „ 253 | *25* ·108 | *50* ·0101 | — | — |
| „ 290 | — | — | — | — |
| „ 517 | *25* ·086 | *50* ·0057 | — | — |
| Richmond | *25* ·084 | — | — | — |
| Kew Bridge | *25* ·138 | *50* ·0103 | — | — |
| Hammersmith Bridge | *26* ·221 | *50* ·0149 | *23* ·0016 | *23* ·0113 |
| Putney Bridge | *26* ·092 | *51* ·022 | *23* ·0006 | *23* ·0092 |
| Chelsea Bridge or Pier | *26* ·165 | *51* ·0114 | — | — |
| Kensington Canal | — | *51* ·0112 | — | — |
| Battersea Bridge | — | *51* ·0112 | — | — |
| Victoria Bridge | — | *51* ·0164 | — | — |
| Westminster Bridge | *26* ·162 | *51* ·0133 | *23* ·0118 | *23* ·1100 |
| Waterloo Bridge | *26* ·160 | *51* ·0133 | — | — |
| Blackfriars Bridge | — | *51* ·025 | — | — |
| London Bridge | *26* ·190 | *52* ·0194 | *23* ·0141 | *23* ·2466 |
| St. Katharine's Dock Entrance. | — | *52* ·0143 | — | — |
| Tunnel Pier | *27* ·126 | *52* ·0175 | — | — |
| Pickling Works, Rotherhithe | — | *52* ·028 | — | — |
| Greenwich | *28* ·157 | *53* ·0178 | — | — |
| Blackwall Pier | *28* ·161 | *54* ·0225 | *23* ·0072 | *23* ·0914 |
| Victoria Docks | — | *54* ·0308 | — | — |
| Charlton Pier | *28* ·115 | *54* ·0165 | — | — |
| Warspite | *28* ·179 | — | — | — |
| Woolwich Arsenal | *30* ·182 | *55* ·0202 | *23* ·0054 | *23* ·0693 |
| Beckton Gasworks | *30* ·237 | *55* ·0207 | — | — |
| Place where "Princess Alice" went down. | *30* ·220 | *55* ·030 | — | — |
| Barking Outfall and Creek | *31* ·235 | *56* ·0534 | *23* ·0063 | *23* ·080 |
| Between the Outfalls | — | *56* ·0015 | — | — |
| Tripcock Point, &c., Crossness Point, &c. | *31* ·210 | *57* ·0242 | — | — |
| Southern Outfall | *31* ·270 | *57* ·0192 | — | — |
| No. 60 | *31* ·287 | *56* ·0159 | — | — |
| „ 61 | *31* ·280 | *56* ·0168 | — | — |
| „ 62 | *31* ·266 | *56* ·0139 | — | — |
| „ 63 | *31* ·280 | *57* ·0129 | — | — |
| „ 64 | *31* ·266 | *57* ·0139 | — | — |
| „ 65 | *31* ·280 | *57* ·0118 | — | — |
| „ 66 | *31* ·294 | *57* ·0097 | — | — |
| „ 67 | *31* ·285 | *57* ·0114 | — | — |
| Halfway Reach | *31* ·182 | — | — | — |
| Belvidere Guano Works | *32* ·218 | *57* ·029 | — | — |
| Jenningtree Point | *32* ·168 | *57* ·0278 | — | — |
| Erith | *34* ·192 | *59* ·0237 | *23* ·0080 | *23* ·0672 |
| No. 47 | *32* ·280 | *57* ·0196 | — | — |
| „ 48 | *32* ·168 | *57* ·0225 | — | — |
| „ 49 | *32* ·175 | *58* ·0263 | — | — |
| „ 50 | *32* ·179 | *58* ·0263 | — | — |
| „ 51 | *32* ·179 | *58* ·0196 | — | — |
| „ 52 | *32* ·233 | *58* ·0364 | — | — |
| „ 188 | *32* ·240 | *58* ·032 | — | — |
| „ 235 | *32* ·151 | *58* ·017 | — | — |
| „ 236 | *32* ·126 | *58* ·017 | — | — |
| „ 237 | *32* ·118 | *58* ·614 | — | — |
| „ 258 | *32* ·218 | *58* ·020 | — | — |
| „ 259 | *32* ·227 | *58* ·015 | — | — |
| „ 260 | *33* ·235 | *58* ·022 | — | — |
| „ 270 | *33* ·213 | *58* ·0218 | — | — |
| „ 271 | *33* ·199 | *58* ·0175 | — | — |
| „ 272 | *33* ·204 | *58* ·0216 | — | — |
| „ 267 | *33* ·148 | *58* ·0143 | — | — |
| „ 268 | *33* ·131 | *58* ·0094 | — | — |
| „ 269 | *33* ·151 | *59* ·0091 | — | — |
| „ 320, 322 | *33* ·130 | *59* ·024 | — | — |
| „ 378 | *33* ·266 | *59* ·033 | — | — |
| „ 379 | *33* ·204 | *59* ·027 | — | — |
| „ 380 | *33* ·314 | *59* ·041 | — | — |
| „ 381 | *33* ·269 | *59* ·033 | — | — |
| „ 382 | *33* ·188 | *59* ·034 | — | — |
| „ 384 | *33* ·164 | *59* ·036 | — | — |
| „ 385 | *33* ·184 | *59* ·035 | — | — |
| „ 386 | *33* ·314 | *59* ·036 | — | — |
| „ 387 | *33* ·241 | *59* ·030 | — | — |
| „ 388 | *33* ·179 | *59* ·035 | — | — |
| „ 389 | *33* ·118 | *59* ·038 | — | — |
| „ 390 | *33* ·148 | *59* ·019 | — | — |
| „ 507 | *33* ·202 | *59* ·0221 | — | — |
| „ 506 | *33* ·182 | *59* ·0165 | — | — |
| „ 522 | *34* ·140 | *59* ·0126 | — | — |
| „ 523 | *34* ·140 | *59* ·0225 | — | — |
| Purfleet | *34* ·155 | *60* ·0178 | — | — |
| Greenhithe | *35* ·144 | *60* ·0168 | *23* ·0028 | *23* ·0304 |
| Northfleet Dockyard | *35* ·128 | *60* ·0124 | — | — |
| Northfleet Light | *35* — | *60* ·0096 | — | — |

11 July 1883.

| Name of Place. | Oxygen absorbed. | Albuminoid Ammonia. Grains per Gallon. | Microscopic. Grains per Gallon. | |
|---|---|---|---|---|
| | | | Fæces, page 23, Sorby. | Excrements, page 23, Sorby. |
| | Page | Page | Page | Page |
| Gravesend | 36 ·106 | 64 ·0134 | — | — |
| Coal House Point | 36 ·143 | 64 ·0178 | — | — |
| Mucking Light | 36 ·076 | 64 ·0064 | — | — |
| Thames Haven | 36 ·080 | 64 ·0069 | 23 ·0000 | 23 ·0028 |
| Hole Haven | 36 ·098 | 64 ·0116 | — | — |
| Deadman's Point | 36 ·092 | — | — | — |
| Yantlet Creek | 36 ·064 | 64 ·0042 | 23 ·0000 | 23· 0028 |
| Southend | — | 64 ·0063 | — | — |

Taking the same water, it has been shown, in a variety of instances, to have improved according to the oxygen test, and to have got very much worse according to the albuminoid ammonia test. And this was no isolated instance; it was brought to the notice of the Commission by Mr. Lumley Smith in the cross-examination of Dr. Duprè in Questions 16,142 to 16,152. Your Lordship with perfect fairness indicated to my learned friend, Mr. Lumley Smith, that there might be some mistake about it. My learned friend, Mr. Lumley Smith, elicited this fact: that in a number of instances, not by any means exhausting the list or anything like it, but only taking five or six, the water which was shown to be getting better by the albuminoid ammonia process was shown to be getting worse by the oxygen process, or *vice versâ*; and your Lordship asked whether that showed anything more than that there was a mistake in the experiment. The witness clung to that straw and said, I think not. My learned friend, Mr. Lumley Smith, said, "We dispute the "Wanklyn process as being one to be relied upon. "We also dispute to a certain extent the oxygen "process as being good; and here you find that, if "you take two figures at random, they give opposite "results." (*Chairman.*) You have taken two specimens? (*Mr. Lumley Smith.*) And no doubt we could produce more. (*Chairman.*) But in a general way they tally, do they not? My Lord, they do not tally in a general way, or anything like it. Then the witness said, "The explanation is very simple. "The two processes—neither of them profess to give "the absolute amount of organic matter." I know they do not. "They must be compared with themselves, and not one with the other. You must not "compare the result by the oxygen process of different kinds of matter with the albuminoid ammonia "process, otherwise you will get discordant results; "you must compare the oxygen process right through, "and see what you get, and then compare the albuminoid ammonia process right through, and see "what you get from them all, and you will then find "the conclusions identical." My Lord, I submit to the judgment of the scientific members of the Commission that that is not so. I am instructed by Dr. Tidy and Mr. Baldwin Latham and others, who have examined it, that it is not true that the results are relatively identical, or anything like it. My learned friend, Mr Bidder, stated that they confirmed each other in the most remarkable way. I submit, upon instructions, that they do not do anything like it. They show that the water which according to one process is seen to be getting worse, according to the other process is seen to be getting better.

I would ask leave to remind you that this fact was called to the attention of a witness by Professor Williamson. Your Lordship having suggested, for the purpose of criticising the particular instances put, that it might be taken to be an error of manipulation. Professor Williamson said, "I think the discrepancy "of the figures can hardly be said to be a mistake in "either case, because each process determines something different from the other. They each attack "the question from a special side, and the quantity "of organic matter can only be judged by a sort of "guess work. Each determination may be perfectly "correctly made within very narrow limits of accuracy, and yet they may differ from each other, "so that each of them gives rather a sort of approximation to the truth than an accurate result." Now I invite the Commission to do this, because, though I am here as an advocate in my own person, yet the Corporation are not here as advocates in the ordinary sense of the word; we invite the scientific members of the Commission to examine these two tables. They were not put in parallel columns by the Metropolitan Board of Works. We have generally seen these things put in parallel columns, so that you might see the one compared to the other, and that we have done for them. I invite each member of the Commission to examine these analyses, and I allege as confidently as I am entitled to do, and as my learned friend, Mr. Bidder, alleged upon the other side, that so far from confirming one another in a pollution point of view, they show that the processes are unreliable.

Now let us approach the case from the point of view apart from results. Are our chemists right, who consider these processes unreliable, or are the Board right, who say they are reliable? Dr. Tidy said, in answer to a question, I know all about the oxygen process,—the particular process now adopted is one which I developed; but it is not reliable because of the evolution of hydrochloric acid. I do not know whether the Commission wish me to go over that, for I have no doubt I might make mistakes in it; but what I understood Dr. Tidy to say was, that in consequence of the evolution of the hydrochloric acid by the oxygen process which consists of putting in sulphuric acid and permanganate of potash, the result is that the test is not reliable. Now Dr. Duprè suggested a closed vessel. Here I am obliged to appeal to the scientific knowledge of the Commission, or to the scientific power of research of the Commission. I am instructed by chemists that doing it in a closed vessel would not eliminate the liability to error; and I am further instructed that they cannot understand how the doing it in a closed vessel would make any difference at all to the defect which Dr. Tidy has pointed out. I only put that to the Commission as part of my argument; you have on one side a gentleman who says he has done it, and on the other side you have Dr. Tidy, who says it is not reliable, and shows why he does not approve of it.

Now, in regard to the albuminoid ammonia process, would your Lordship kindly refer to questions from 15,777 to 15,814. Of course I am not going to read them; but every question will be found to be most important upon this particular matter. I will sum them up as I understand them, having read them more than once. They amount to this, that there are a number of things which get into the river perfectly independent of sewage which will produce albuminoid ammonia. I will ask you to refer first to Question 15,077, in which uric acid and urea and several other things are pointed to, and admitted by, Dr. Duprè to yield albuminoid ammonia, and yet not of necessity in any way connected with sewage.

(*Mr. Michael.*) Where do you say it is admitted by Dr. Duprè?

(*Mr. Webster.*) If you will kindly read questions and answers 15,777 to 15,814——

(*Mr. Michael.*) I have read them.

(*Mr. Webster.*) I submit to the judgment of the Commission whether that is not strictly accurate.

(*Mr. Michael.*) But that is the evidence of Mr. Dibdin, and not Dr. Duprè.

(*Mr. Webster.*) Quite so. I beg the pardon of my learned friend and of the Commission; the numbers of the questions and the facts were correct, but the name of the witness was wrong. Now I call attention to question 15,616, in which Professor Williamson pointed out the liability to error of the albuminoid

ammonia test, as compared with the other tests. My argument to the Commission, worth very little from me, but worth a good deal more when coming from the judgment of a competent gentleman, and submitted, as it is, to the judgment of competent gentlemen, is this: We know that the albuminoid ammonia and the oxygen tests are very unreliable, but that you must rely upon the combustion process, which will give you the actual amount of organic carbon, the actual amount of organic nitrogen, and, of course, the relative amounts. Now I shall have a word to say upon the matter of the albuminoid ammonia directly in connexion with free ammonia; but I pause in order not to lose the order in which the matter has been suggested to me. I ask the Commission to regard the value of this scientific evidence. I say that Dr. Tidy showed that at Teddington there was very little solid matter in suspension indeed. He showed that at Teddington the organic carbon was two parts per 100,000, that the free oxygen was two cubic inches per gallon, and that there was practically no ammonia. That I submit to the scientific judgment of the Commission is what Dr. Tidy showed as perfectly as it can be shown in the present condition of water analysis. Whether he is perfectly accurate in every detail he submits to the judgment of those who judge him in this matter; but that is the broad result of his evidence. Now, I venture to submit, taking his diagrams, and taking his tables, without denying that there are local ups and downs due to local causes, that, reach by reach, from Greenwich to Beckton the organic carbon increases, until you have at Greenwich three times the amount and at Beckton four times the amount that you have at Teddington. The diagrams are before you, but you will have this before you in print, and you will observe what I say. Concurrently you have a decrease of free oxygen, until at Beckton you have only half a cubic inch, as against two inches at Teddington. I say it by no means follows that the effective operation, from a purification point of view, of half a cubic inch of oxygen would be a quarter of the two inches, because, as Dr. Odling pointed out, as far as his experience goes, the effective operation decreases more than in exact proportion to the diminution of volume. Now, what do our witnesses say is the result of the evidence. That the oxygen was burning up the organic matter, the oxygen itself becoming exhausted, the organic matter still increasing. And I ask your Lordship and the Commission to judge whether this is not the correct result of Dr. Tidy's analysis, assuming the analysis to be correctly taken, and, of course, assuming (as I trust I have satisfied your Lordship) that the albuminoid ammonia and the oxygen tests are not reliable, viz., that, reach by reach, the increase of the ratio of organic nitrogen to organic carbon, whereas it was at Teddington 1 to 7·7 is at Vauxhall 1 to 6, at Greenwich 1 to 2·9, and at Beckton 1 to 2·5. We submit to the chemists on the Commission that that shows clearly that that pollution or alteration of the circumstances is due to animal and not to vegetable contamination.

I am not going over it again. I will admit, my Lord, that I am only, as it were, an educated parrot in this matter. I only want to bring the argument before the Commission; it does not commend itself, as I hope points of law would, because I have exercised a judgment upon it; but I have only endeavoured to grasp it, and to bring it to the minds of those whom I address.

(*Chairman.*) Bear in mind that you, if an educated parrot, are addressing, as far as I am concerned, an uneducated parrot.

(*Mr. Webster.*) Not altogether, my Lord; at all events, your Lordship will remember that there are birds in the nest who are educated, and who can assist you. I desire to formulate, as clearly as I can, the argument as I understand the evidence, and to indicate those points simply to the Commission.

(*Chairman.*) Would you, in plain English, which any bird could understand, tell us what it comes to. It comes to this, you say there is a greater quantity of putrescible (I suppose that is the word) matter in sewage than they allow upon the other side; is that so?

(*Mr. Webster.*) No, I go past that. I say in the river.

(*Chairman.*) I meant in the river.

(*Mr. Webster.*) I am not now dealing with the constituent parts of the sewage. I am dealing with the result of analysis of the water as it exists in the river itself. I will show you why I regard it as of considerable importance.

(*Chairman.*) If you are agreed as to the amount of putrescible matter in the sewage——

(*Mr. Webster.*) That simplifies the matter enormously.

(*Chairman.*) But you still might differ as to the quantity in the river.

(*Mr. Webster.*) Certainly.

(*Chairman.*) Because one side would say there is a greater mixture, and the other side would say there is a greater destruction.

(*Mr. Webster.*) No doubt; that the oxygen was burnt up to a larger extent than the other side would be inclined to admit. Now I was submitting that if these figures are right, which again I respectfully ask the judgment of the Commission upon, that the pollution or alteration is due to animal and not to vegetable contamination. At Question 16,554 I think your Lordship will find that, in substance, the deductions of Dr. Tidy from his tests, assuming his tests to be correct, and assuming the process to be correct, are agreed in by the other side. The fact of the matter is this, that if Dr. Tidy and Dr. Frankland are correct in saying that the combustion process is the more reliable, and the best guide to indicate to the Commission the actual state of things, the conclusions which I draw from the combustion process will not be disputed by the chemists upon the other side, and the state of things at the outfall, as compared with up the river, will not be denied by the chemists on the other side; but what they do say is, we think, that for this purpose the albuminoid ammonia and the oxygen test is the better test, and do not rely upon the combustion process. That is why I venture to attack the one method of examination, as compared with the other method of examination.

Now, concurrently with the increase of the ratio of the organic nitrogen to the organic carbon, your Lordship will remember the same diagrams showed a decrease of free oxygen, one line went up and the other line came down; and that was attempted to be met in this way. It was suggested that, because there was much more sea water down at the outfalls, therefore there would be less free oxygen in the constituents which had been examined. Now I must ask your Lordship to observe what Dr. Tidy has called attention to at Questions 10,221 to 10,225, and 10,217 to 10,218, and at 9872, in which he says that, as the result of many experiments, the quantity of free oxygen in sea water and in river water is, practically, identical; and that, therefore, the diminution of free oxygen, or the decrease of free oxygen, in the samples of water, cannot be due to the difference between fresh and sea water.

Now only one analysis has been given to rebut that statement; only one suggestion; and that is from that analysis taken at Southend. I think it was taken by Dr. Duprè, though I may have made a mistake about the name, but I think the Commission will find it is from a sample taken by Dr. Duprè at Southend. Now whether a Southend sample, which might be more or less contaminated by sewage, would be a reliable guide, I submit to the Commission as a matter of doubt; but I rely upon that which was put by Dr. Tidy in the forefront of the argument, that, in his judgment, the free oxygen in the sea water was, for these purposes, identical with that in the river water, and in that Dr. Odling agrees with him at Question 16,471. Now I do not say that the purifying power of the water varies exactly with the free oxygen, for

11 July 1883.

at Question 15,572 Dr. Odling practically shows that if you reduce the quantity from two cubic inches to half an inch it by no means follows that the purifying power of the water from the oxygen point of view is a quarter of the larger quantity.

I have brought before your Lordship's mind, and I trust before the mind of the Commission, such criticisms upon that part of the chemical case, as I think it right to present to you. There are two or three minor matters, but still matters of importance, which I will notice as I pass on. One is the importance of the free ammonia, and here I may profess (having a little smattering of knowledge upon this part of the subject) that I did expect to find that when they produced the albuminoid ammonia test, they would have told us what the quantities of free ammonia were, because I am told that they must get rid of the free ammonia in order to determine the albuminoid ammonia; therefore it is knowledge that has passed through their hands, so to speak, or which has passed under their attention. Now, I would ask your Lordship to refer to Question 9870, where Dr. Tidy is asked "You have told us that in the upper Thames "water the ammonia is nearly nil. (*A.*) Nearly nil. "(*Q.*) And in sea water it is also nearly nil? (*A.*) "Yes, in sea water also it is nearly nil. (*Q.*) That "will be of importance when you come to try to "trace the sewage? (*A.*) It will; the question of "the ammonia will become an important one. Then "another thing to be noted is the very small quantity "of nitrogen as nitrates in sea water." Your Lordship will find upon the table, and the chemical members of the Commission will find upon the table, put in by Dr. Tidy, an analysis of free ammonia put in for each sample. Now will your Lordship turn to Dr. Frankland's evidence; at Question 10,748 he is asked "But we have heard that ammonia is very "evanescent," he had been referring to the ammonia test above, "does that qualify what you have said with "regard to the value of the ammonia test," to which he replied, "Yes, it qualifies it in one direction, as "I think I mentioned upon the last occasion. "Where you find this excess of ammonia it is "positive evidence of the presence of sewage, but if "you do not find ammonia it is not positive evidence "of the absence of sewage; the ammonia is "evanescent, it rapidly disappears;" and I am instructed, my Lord, and I put it to the Commission, that to have ascertained the quantity of free ammonia in these samples taken, there being admittedly little, or I would rather say, no free ammonia in the Teddington water, and none in the sea water; and there having been put in a table by Dr. Frankland and Dr. Tidy pointing to this; and there having been no cross-examination of them as to whether the ammonia test was not most important, I think that if it be true that in ascertaining the result by the albuminoid ammonia process, you would get the amount of the free ammonia, it would have been important to have that information given to the Commission, if Dr. Tidy's evidence was going to be disputed.

(*Chairman.*) Were any of the witnesses asked that.

(*Mr. Michael.*) There is a column for free ammonia in our analyses.

(*Mr. Webster.*) It is only in Mr Dibdin's, and I think I may say that it has never been used. I am told that it does occur in some of the samples of Mr. Dibdin's, it does not occur in Dr. Duprè's.

(*Mr. Michael.*) I have Mr. Dibdin's tables before me.

(*Mr. Webster.*) But I am told it is not in the other one's.

(*Chairman.*) That is a somewhat serious question, because you appear to suppose that these gentlemen knew something, and suppressed something.

(*Mr. Webster.*) No. I do not wish to put my case a bit higher than I ought to do. These gentlemen are wedded to the albuminoid ammonia and the oxygen process. I say that there are known tests which they ought to have used, whatever their value may have been, to have checked that which they thought was a reliable guide.

(*Chairman.*) Was anyone asked as to it.

(*Mr. Webster.*) I am not sure, my Lord.

(*Mr. Michael.*) No, there was no examination about it.

(*Chairman.*) Mr. Michael has the advantage of you, because he is certain.

(*Mr. Webster.*) It was never used.

(*Chairman.*) I do not know whether the scientific members of the Commission will understand the value of the point, I confess I cannot.

(*Mr Webster.*) I cannot myself profess to understand it.

(*Chairman.*) I cannot help thinking it strange that the chemists were not asked it. At *nisi prius* one would say of course they did not dare ask it.

(*Mr. Webster.* I am not conducting this case, as your Lordship knows, in a *nisi prius* manner. The only criticism I want to found upon it is that this is an additional reason for not relying on, what I have described as the inconsistent results of the albuminoid ammonia and the oxygen process. It is not as if all the Commission were obliged to be only in your Lordship's position of judging of the matter as a question of fact.

*Mr. Michael.*) If your Lordship will kindly turn to Question 10,748, Dr. Frankland, their own witness, says it is of no importance; it is no indication whatever.

(*Mr. Webster.*) I read that a moment ago to my Lord Bramwell and the other members of the Commission.

(*Chairman.*) He says, "If you do not find it, it is not positive evidence of the absence of sewage." What you say is, that these gentlemen must have found it, and have not noticed it.

(*Mr. Webster.*) Yes, that they could have found it; and I am instructed that they must have found it. That they could have found it, if Dr. Tidy is instructing me correctly, is clear; of that the members of the Commission must judge.

(*Chairman to Dr. Duprè.*) Did you find it?

(*Dr Duprè.*) Certainly; but there were already so many figures, and we thought it was really no positive indication, not so valuable as the albuminoid ammonia test; and in order to avoid too great a number of figures, we left it out. We found it in every case.

(*Chairman.*) You did find this free ammonia?

(*Dr. Duprè.*) Certainly. There are many things left out in order to keep the tables clear.

(*Mr. Webster.*) I only call your Lordship's attention to it to show that you ought to hesitate before adopting the view presented by the Metropolitan Board as to the chemical part of the case. I was only doing my duty in reference to Dr. Frankland's positive evidence with regard to it, and to Dr. Tidy's statement that it was of importance, as to the deductions which they drew from the ammonia. If I am right in saying that the albuminoid ammonia is not a reliable test, nor the oxygen either, it does make the free ammonia of the more importance.

Now, upon the microscopic evidence. We have Dr. Tidy and Mr. Lionel Beale telling your Lordship that which was new to the scientific world, I believe, namely, that the spirals and the amorphous matter are undoubted indications of the constituents of sewage, and the witnesses said, without attempting to do it quantitively, that they considered there was an undoubted increase from Chiswick to Crossness. Now, my Lord, Mr. Sorby, who for the first time has evolved a theory of quantitative microscopic analysis by means of measuring the field which is examined, assuming his plates are placed at the same microscopic distance apart in each instance, has been able to say, not that there are less of these particular things, but that there are other counteracting influences which, in his judgment, destroy any baneful effect which might be brought about by the presence of such things. Now, it is admitted that Mr. Sorby's method depends upon the skill of the operator. You will

recollect the question I put to him, and I trust the Commission will very, very carefully consider how far they will be justified in acting on these facts and conclusions derived from Mr. Sorby's examination. I am instructed that such an operation is one of exceeding difficulty of manipulation as was admitted by Mr. Sorby, and it must of necessity involve a considerable liability to error, and probably the existence of a good many errors, and it cannot be relied upon for the purpose of forming a safe guide.

My Lord, there is one criticism which I can apply to this. I pointed out, and I remember Sir John Coode pointing out, that I was well founded in my observation, that Mr. Sorby made the water lower down the river materially better than it was near London Bridge; and there are numbers of instances in his cross-examination showing a much worse water higher up than lower down. Now, whatever view you may take with regard to what was the state of matters between Woolwich and Purfleet, which is the area I am coming to directly, I shall submit to your Lordships, upon the evidence, that nobody pretends that the same thing had been even possibly complained of above Greenwich. Your Lordship said more than once, We are all of opinion that the evidence of real nuisance (I am not speaking of the exceptional nuisance) is certainly below Greenwich. And I ask your Lordship to remember that nobody, until Mr. Sorby came, ever suggested viz., that the same kind of appearances as were said to have taken place, truly or falsely, below Barking and Crossness, ought, in fact, to take place at London Bridge, if the story were true. And what I think would be a not unfair commentary in addressing a jury upon this matter, would be, that if Mr. Sorby's allegation is true, it is inconceivable that everybody should be practically agreed, that whatever it may be chemically, and whatever it may be microscopically, the water at London Bridge is practically better than the water down below.

(*Chairman.*) I think we all noticed that at the time.

(*Mr. Webster.*) I ask your Lordship, when you and the Commission come to deal with the matter, to remember that the microscopic evidence is far more properly dealt with by Dr. Tidy and Mr. Beale, as corroborating the qualitative results and not the quantitative results, than it is by Mr. Sorby, in the very learned and interesting way in which he dealt with it.

I am glad to tell your Lordships that there are only two other small matters which I have to notice upon the scientific part of the case, and I will pass them over as shortly as I can. One is with regard to the actual origin of the muds. At Question 10,692 Dr. Frankland pointed out that the muds of the upper Thames were chiefly vegetable; at Question 10,693 he pointed out that the muds of the Lower Thames were chiefly animal. Now, I am not upon the question of pollution or not, for the moment, I am only following out the general line of thought, whether it is contamination by animal matter as distinguished from vegetable matter; and I was amused by my learned friend, Mr. Bidder, trying to catch your Lordship with the argument, that because some fishermen said there were worms, and some that there were not worms, that the worm question had nothing to do with it, but the real fact was that these people did not possess the power of discrimination between worms, except as regarded worms for the purpose of bait. Dr. Tidy is, however, competent to deal with it, and I ask you to consider his evidence upon it.

Now, would your Lordship bear in mind a point referred to and relied upon by Dr. Tidy with considerable emphasis, which followed upon a question put by the Commission. If your Lordship will look (I will not read it) at Question 10,001, your Lordship will find a suggestion made by Professor Williamson to Dr. Tidy. I put it in the language given to me, which, I think, is correct, as to whether the sulphates of sea water would not become reduced to sulphides by the organic matter of the sewage. Dr. Tidy stated that it was a matter of considerable importance, and that he was going to deal with it presently; and at Question 10,676 your Lordship will find he puts it distinctly. He refers to the chemical action suggested for his consideration by Professor Williamson, and agrees entirely with the view put forward which, he said, he had previously considered, and to which he attached importance. It all has an important bearing upon the action of these elements upon the water into which the sewage is turned. 11 July 1883.

Now, I will only notice in passing that, practically speaking, the only remedy which the Board rely upon is, first, the oxidation of the sewage by the oxygen of the water, and, secondly, the existence of a large amount of invisible water which Mr. Law has discovered. I do ask your Lordship to kindly consider the questions which I put to Mr. Law as to where the water was to come from which was to produce the invisible underground supply, and also the number of square miles it would require; and I think I pointed out that the figures he quoted from Dr. Priestwich's book were figures prepared from an entirely different standpoint.

(*Chairman.*) I think Mr. Law admitted that he could not swear that the whole of it did not find its way out 1,000 miles into the Atlantic, except that he pointed out some particular channels in the chalk as to which that could not be so.

(*Mr. Webster.*) That was so. Now I have, without, I hope, occupying more time than I ought to have done, called attention to the great matters of principle with regard to the samples part of the case. I will only say on leaving it, that if your Lordship will kindly refer to certain comparisons made by my learned friend Mr. Bidder, the multiplication of quantities or numbers of grains by the amount of organic pollution, and things of that kind taken from the tables, your Lordship will find that he was in all instances he quoted, taking waters of different days, and comparing them together; and further than that he was taking in his Barking instance 4·016 which was the figure he quoted, as an instance of a particular sample at Barking; whereas upon the same table by the same chemist, next door to it, were two samples taken upon the same day and at the same time, showing instead of 4·016, 7·57 in two instances. I only call attention to this for the purpose of submitting to the judgment of the Commission, that they must not take, and they would not take, without examination, my learned friend Mr. Bidder's calculation; but I am instructed that if you examine them they are comparative calculations which do not refer to one another, but refer to different days, and should be taken, if taken at all for the purpose of comparison, with the samples taken upon the same day, and at the same part of the river. Now I come to the question your Lordship has put pointedly to us more than once, "After all no matter what your doctors say, "Does it or does it not stink?"

(*Chairman.*) Has any question of this sort been suggested, that if you took a given part of the sewage and a certain number of parts of unpolluted water and shook them violently together, the sewage would be much sooner burnt up or destroyed, than if you were gently to pour the sewage into the vessel.

(*Mr. Webster.*) It depends upon the chemical combination. I am not chemist enough to answer your Lordships' question.

(*Mr. Michael.*) It would be so.

(*Chairman.*) If you have a large body of sewage coming out at once, it flows in a marked stream down the river, as we saw, and it reminded one a little of the Rhone and the Arve, where the Arve continues unmixed with the Rhone for a long way, and until the mixture is complete the oxidizing does not take place. Does not that make the scientific evidence, I will not say comparatively of less value, but more uncertain.

11 July 1883.

(*Mr. Webster.*) May I be allowed to tell your Lordship how I regard it. Your Lordship has had put before you on both sides a mass of scientific evidence and scientific facts. The Board of Works come here in the discharge of a public duty, and they tell you that the existing system is either as good as it can be or not so bad as to call for a remedy under any circumstances. The only reason why I am referring to it is to prevent your Lordship and the other members of the Commission, if I can do so, from without due consideration, reporting something which would apparently prejudge the question from a scientific point of view; and I should like now to occupy your Lordship for a little time with regard to what the evidence really shows.

Now, I confess, though I have not had the advantage of perusing my learned friend Mr. Bazalgette's notes (my learned friend, Mr. Bidder, told us how much he was indebted to him in the matter), they must have been notes most cleverly and cunningly prepared, for they enabled my learned friend Mr. Bidder to steer clear of some of the most remarkable difficulties of evidence that it has ever been my lot to consider. My Lord, a great quantity of this evidence was taken a year ago; it has passed away to a certain extent at any rate in detail from your minds. My learned friend, Mr. Bidder, told your Lordship on Monday, that a particular witness, a witness of the highest respectability, as I will show you presently, and having the fullest opportunity of judging, must have been mistaken, because he had made a statement with regard to the comparison between the water in the year 1858 and the water in the year 1881, which could not be believed. I will show your Lordship, and I confess, except that I know how much he has to do, I was surprised that it did not occur to my learned friend Mr. Bidder to see how many people absolutely corroborated that, both chapter and verse, from independent sources and independent evidence, from statistics and entries made at a time when they could have had no knowledge whatever of what that man was going to say.

Now what I am going to put before your Lordship is the issue, which I say we have proved. I say we have proved this: that not at all times of the year, of course not, else this Commission would have been sitting years ago, but that after a continuance for a month or six weeks of serious hot weather, there does rise from the mud, and there do exist in the water black masses which break up, which give off noxious gases, which are most offensive to the individual who comes in contact with them, and which have had effect upon health. My Lord, I, at any rate, have had too much experience to ask your Lordship even to hear me upon an issue, unless I thought I had substantial evidence to support it, and I am not going to contend before the Commission that we have proved at present a serious injury to health. Your Lordship indicated, I do not think in any way prejudging the question, if I may say so, to my learned friend, Mr. Bidder, that you were all pretty much of that opinion. Now I recollect a very clever answer which was made by a lady to my learned friend, Mr. Benjamin, when he was cross-examining her as to an alleged nuisance. She said, "Well, if you call a "nasty taste in your mouth, and a feeling of not being "well, and not being able to do much,—a nuisance, "that is what we experience, not that we have called "in a doctor." Now, I say, it has already amounted to that which in that point of view does constitute a serious nuisance.

(*Chairman.*) I thought you were going to call attention to the gentleman who gave that evidence as to the state of the water in 1858.

(*Mr. Webster.*) I am coming to that directly. Now what occurs in bad times produces, as it is alleged, a feeling of *malaise*, and to a certain extent of nausea, not which does affect the health at present, but which might become very much more serious. Now you were invited to go any day you liked and smell it. My learned friend, Mr. Bidder, asked you, Did you smell anything when you were there? We know very well that if the river were always as it was when you went down, this Commission would never have been asked for. I ask you as judges of the facts in this case, to say, that unless there is the most distinctly, deliberate perjury in this matter, there has been positive evidence of facts. Witnesses corroborating one another as to this state of things to a far greater extent than my learned friend Mr. Bidder will admit; he has called it mistake; he has called it exaggeration, we will see in a moment or two whether it has been so or not.

Now I disagree here. I leave that to my learned friend, Mr. Beaumont Morice, the evidence of men like fishermen and lightermen, who may exaggerate, or who may be mistaken, but with this one observation. It is not because my learned friend, Mr. Bidder (as Sir Benson Maxwell pointed out to him at the time), put the conversation into the witness's mouth, and that witness said, that that conversation took place, that your Lordship and the Commission would entirely disregard it; that is a very useful way of suggesting a conversation in cross-examination; but I do not think in a matter of this sort, that you would pay much attention to it.

(*Chairman.*) I do not recollect the particular case to which you refer.

(*Mr. Webster.*) I will take the case of the witness Cobb. My learned friend Mr. Bidder has over and over again reverted to it. He was asked in effect. You were present at the conversation at the "Golden Anchor." Sir Benson Maxwell pointed out to him, I think it was in this case, that he was putting the conversation into the witness' mouth, and my learned friend Mr. Bidder has always assumed that the whole of these fishermen's evidence was got rid of by means of this fishing and clever cross-examination.

(*Mr. Norman Bazalgette.*) You will find it at Questions 1356 to 1370.

(*Mr. Webster.*) I will take Question 1353. Cobb was asked "Who asked you to come here and give "evidence?" To which he replied, "A gentleman "who comes from Greenwich, I believe. I do not "know his name. (*Q.*) Did you have a meeting "about this a week ago? (*A.*) He asked me if I "would collect as many fishermen as I could "together, and I did so. (*Q.*) Did you have a "meeting at a public-house. (*A.*) We did. (*Q.*) "What was the name of the place. (*A.*) The "'Golden Anchor.' (*Q.*) Was that the anchor you "lost. (*A.*) No. (*Q.*) One you often hanker after, "I dare say? (*A.*) No doubt." This is all very amusing and funny. Then he is asked, "How many "of you were there," and his answer was, "About a "dozen of us. (*Q.*) Who were there? (*A.*) I do "not know the gentleman's name, but he is here. "(*Q.*) Did he make a speech." Now there he is not right, for the witness says, "He asked us to "collect the fishermen, and he asked me in par-"ticular, as I was the oldest fisherman there, to "collect the fishermen together, to see what we knew "about it. (*Q.*) After that, I hope he behaved "handsomely to you? (*A.*) We had several pots of "half-and-half. (*Q.*) After having had these pots "of half-and-half, did he address you on the subject? "(*A.*) Yes. (*Q.*) He told you what he wanted you "to do,—to find fault with the sewage? (*A.*) Yes. "(*Q.*) Did he ask you how far you could help him? "(*A.*) Yes, he did so. (*Q.*) He asked you if you "could say the fish had gone out of the reach? "(*A.*) Yes, he did. (*Q.*) He asked you if you "could say that you had seen the sewage run down "the reach. (*A.*) Yes." It is the commonest common jury trick that ever has been done.

(*Chairman.*) As you have been reading that I was anxious to see if I was in the chair, and I find it was not myself, but that it was Sir John Coode. You have heard me before, a good many times, but I have always said, "You are not cross-examining, you "are putting words into the man's mouth, and asking "him if he agrees with them." Such evidence as

that is not worth a fig. A poor man sees a gentleman of considerable position, while he is only a fisherman.

(*Mr. Webster.*) And he would naturally accept the proceedings very much as they were put to him.

(*Chairman.*) I am sure that the witnesses called on both sides are respectable people, and that the intention of those who call them is that they should tell the truth, and it is quite possible that Cobb, under the genial influence of a pot of beer, made it a little stronger than it was, but you would not on that account refuse to accept it altogether.

(*Mr. Webster.*) No, I would not say so. I would say it was exaggeration; but because my learned friend Mr. Bidder performs that not very wonderful feat of putting an entire conversation into a man's mouth, I think he is not entitled to say that the evidence is worth nothing. Now, much of this evidence is given by men who are capable of giving your Lordship evidence of value. I will ask your Lordship to refer to Dr. Jessett's evidence, at Question 4460, on page 22, where he was asked, "Do you "still think that the sewage passing down the river "is likely to exercise an evil effect? (*A.*) I have "not a doubt of it. I myself have been yachting. "Only last summer I went out yatching, and kept "coming up with the flood tide, and when the tide "came up there were large masses of sewage, as "large as the table in front of me, floating about, "and ladies on the yacht were sick, and could not "eat their tea on account of the atrocious smell from "those masses of sewage that were floating about in "the river, and that was on the flood tide, and not on "the ebb." He is the medical officer of health for the Erith district. Now that gentleman may have a strong feeling about it, but nobody can say that that is imagination. Here is a medical man saying that there are masses, not in the whole of the river, but floating about in the river. Those are masses, they are not smells from the factories, but visible masses.

(*Chairman.*) Do you go to the extent of saying that the evidence shows a nuisance to people on the land?

(*Mr. Webster.*) No; upon the land away from the river as distinguished from the very boundary of the river, not, but I think I put a question to Sir Joseph Bazalgette, for which your Lordship a little reproved me, by asking whether Sir Joseph Bazalgette was the judge of that, and not the Commission. But I submit respectfully, that to the port London this is of very considerable importance, because there is a very considerable floating population, and a considerable number of vessels coming up to the port of London.

Now I will not refer to Dr. Frankland and Dr. Tidy again, except to remind you that Dr. Frankland said that in his judgment distinctly the river was getting worse.

(*Chairman*). I do not think Dr. Tidy did that.

(*Mr. Webster.*) Dr. Tidy spoke to seeing the sewage bubbling up.

(*Chairman.*) Would you give me the reason why it should get worse—the population gets larger, but it is only in that sense?

(*Mr. Webster.*) I should consider in the first place that the growth of population is one cause. I should consider again another cause is that the banks of the river became more foul in their deposit, and upon that I desire to remind you of the evidence, which I did not hear alluded to in my learned friend Mr. Bidder's speech, of the foul condition of anchors and cables, and nets and things of that kind which are brought up from the bottom of the river: it has not been referred to at all, and yet people of undoubted respectability have spoken to the fact.

(*Chairman.*) And having to wash the gravel and things that they bring up.

(*Mr. Webster.*) Yes, and having to boil the clothes of a large number of the bodies of those who were brought out of the river after the "Princess Alice" accident in order to get rid of the foul smell.

(*Chairman.*) What do you say as to Sir Frederick Abel's evidence.

(*Mr. Webster.*) I will deal with that at once. Sir Frederick Abel is a gentleman of the highest position, and of course a friend of a great many in this room. I am glad to say that I also have the honour of his friendship. He goes out to the terrace at Woolwich to get his fresh air. Such is what he goes through in the course of the day, that it is fresh air to him when he goes out and takes his walk there, and I think a man is justified in saying, and I shall refer to it again when I comment upon the remarkable absence of witnesses upon the part of the Metropolitan Board of Works as to this fact. I say I cannot help thinking that when Sir Frederick Abel has been out there for fresh air when the sewage at Woolwich was bad, that the frightful smells that have been evolved in the process of the chemical and gunpowder experiments there, which he has gone through for so many years have seriously impaired his nasal organ; and I certainly should not like to accept as a test of the smells which come from the sewage, the evidence of a gentleman accustomed to the frightful smells which comes from the detonation of bad gunpowder and other explosives.

(*Chairman.*) Sir Frederick Abel says, if you go into the sewage stream you smell it for 1,000 yards, and after that you do not smell it unless you shake it up in a bottle, and after about another mile you cannot smell it any way.

(*Mr. Webster.*) But he goes further than that—he describes it, when he is only a few yards from the stream itself, as a "faint whiff"—that is when he is 50 or 60 yards away; and I cannot believe in the nasal organ of anybody who, at that proximity, describes the smell of the outpouring sewage as a "faint whiff."

(*Chairman.*) I want you to couple that with the evidence of Captain Burstall; he says he smelt it at Woolwich. Now we have had it proved by the Metropolitan Board of Works that undoubtedly when the tides are making, it does come back to Woolwich. According to Sir Frederick Abel, that is three miles from the outfall, and it ought to have ceased to smell by that time whereas Captain Burstall says it does smell. Now, we have evidence that there is sewage sent out nearly opposite Woolwich from the East Ham outfall, and we have this, that intermediate between the two places, Woolwich and the Barking outfall, there is a training ship which one would think would hardly be put where there is such a nuisance as you mention. I refer to the training ship "Cornwall." Now I know there are not many people living between the two places, but I do not think there is a single witness who has occasion to cross the river who complains of the smell. It looks a though it might be argued that the smell which Captain Burstall smells at Woolwich is not the smell of the outfall.

(*Mr. Webster.*) I will ask your Lordship to let me bring before you a few answers to show that it cannot be disposed of by anything of the kind which has been suggested. Now, the age and the experience of Captain Burstall being admitted by my learned friend Mr. Bidder, all he can say is that his nerves have destroyed his judgment. Now, I would ask your Lordship to look at the way in which Captain Burstall has given his evidence at Questions 6423 to 6426. He says "In cold weather you may get the mud up "from the bottom of the river almost opposite the "outfall, and you cannot smell it. In cold weather I "have got the mud up from the middle of the river "opposite the sewer, and in many other places, and "you cannot detect any smell from it." Now is that the evidence of a man who is unable to exercise his judgment and who simply comes up and smells the river, and, though he lives upon the river, yet, from a nervous fear, concludes it is all sewage? I ask your Lordship how can you account, not for this only, but for a great deal more, to which I will call attention in a few minutes? Unless you can dispose of this by saying it is a mistake, a thing for which some other origin can be traced, there must be some absolute ground for it in matter of fact.

11 July 1883.

Now, would you refer to the evidence of Mr. Lewis, as to whom my learned friend Mr. Bidder did not hesitate to say that he must be mistaken, and did not refer to the remarkable corroboration there is of his evidence. Mr. Lewis begins at question 5020 and he refers to the year 1880, and I ask your Lordships to remember what I say, his evidence is that, whereas in 1858 the river was, as a whole, a stinking sewer, in 1880, there were in patches that which was matter of the same kind. Some of the Commission may remember what the condition of the river was in 1858; my learned friend Mr. Bidder referred to his personal experience upon one point, and perhaps in this tribunal I may say that, happening to be taken by my father in 1858 over the new Westminster Bridge works, which were then being constructed, I remember that the river then running as a black sewer and was offensive to the last degree. Now I ask your Lordship to notice the date. This is the port sanitary inspector, and speaking of July 1880 he says, in answer to question 5,020: "It was in "black patches, it seemed like floating mud as it were, "in black stinking matter. As soon as you touched "it, it tumbled to pieces. This black floating stuff "on the water seemed as if it came from the bottom, "as though it had been drawn up by the heat. "(*Q.*) It seemed to have come up in patches from the "bottom, and then it floated on the top. (*A.*) That "is so. (*Q.*) Did it break up then, or did it break "when it was touched. (*A.*) It broke up at the "slightest touch. (*Q.*) But the patches might be the "size of a table, or they might be the size of a room; "what was their size. (*A.*) They were all kinds "of shapes, the large ones would be about six to "eight feet in length, and the small ones would be "about half that, and their breadth would vary from "three feet to six feet, speaking roughly. (*Q.*) Did "they have the appearance at all of common Thames "mud. (*A.*) Oh no, not at all. (*Q.*) Was there "anything else about it, was it offensive in any way? "(*A.*) Very offensive. (*Q.*) In what way? (*A.*) "There was a fearful stench with it. (*Q.*) This you "say was in July 1880; did that last for any consi-"siderable time in 1880? (*A.*) It lasted nearly the "whole of the month of July, up to the early part of "August, and then it came on to rain, and there was "a thunderstorm, and down went this thick stuff, and "it did not appear again during the wet season after "the rain came. (*Chairman.*) Never again? (*A.*) "Not then. (*Mr. Lumley Smith.*) Had that occurred "before within your knowledge? (*A.*) In 1858." Then I want to refer your Lordship to question 5,041, because this shows that I was correct in my estimate which I had formed of the man. He was asked "In "July 1880 these patches did not pervade the Thames "for the whole of the year; but in other parts of the "year have you noticed anything in the river at all; "has there been any change in the character of the "river? (*A.*) Yes, after, say, 1864, the river seemed "very good, and during these last six or eight years, "speaking roughly, the river has assumed rather a "bad character, it has been getting gradually worse "than it was prior to that time. (*Chairman.*) What "do you mean by 'getting worse'? (*A.*) Take the "northern outfall or the southern outfall; the river "there assumes a very black appearance, and smells "very badly. (*Q.*) Then what you mean by its "'getting worse' is that it is getting blacker and "smells worse? (*A.*) Yes. (*Sir John Coode.*) Within "the last six or eight years? (*A.*) Yes. (*Mr. Lumley "Smith.*) Has there been any recurrence of this "appearance of the patches since July 1880," and so on. Then I should refer you to question 5032 where the witness was asked: "In 1858 do you remember "anything similar to what you saw in 1880? (*A.*) "There was a greater amount, and it lasted for a "longer time (*Mr Bidder.*) Was it worse? (*A.*) "Yes, because these patches extended the whole width "of the river, in fact then it was a black ditch? "(*Q.*) The same same sort of thing as occurred in "in 1880, but much worse? (*A.*) Much worse." Now that was what was referred to by my learned friend Mr. Bidder on the last occasion, and stated to be a mistake; he said it must be a mistake, because he was referring to Cherry Garden which is up at Rotherhithe, and it was said he must be wrong. Would your Lordship kindly oblige me now by referring to Captain Marsden's evidence at question 5355.

(*Chairman.*) But Mr. Lewis says that was in a different part of the river.

(*Mr. Webster.*) In 1858 he says the river was like "one whole black ditch."

(*Chairman.*) That was in a different part of the river; I think Mr. Bidder said there must be some mistake because he found the same thing in 1858 as he does now; whereas the witness says it is a different part of the river, though in a part where it might have been from a similar cause.

(*Mr. Webster.*) But that is not my learned friend Mr. Bidder's only criticism. His criticism was that because in 1880 these black patches existed up to Cherry Gardens, which is up at Rotherhithe, the witness must have been wrong: he must have been confusing his recollection; and my learned friend put it most forcibly to you upon the point.

Now, would your Lordship kindly refer to Captain Marsden, the harbour master, who could not have known what Mr. Lewis was going to say. Reminding you, that the period spoken to by Mr. Lewis, the sanitary inspector, is July 1880, at question 5356 Captain Marsden was asked, "Have you notes of those "observations with you? (*A.*) Yes," and the witness thereupon handed in a paper. Now, this is an extract from a journal entered at the time by the harbour master, a most respectable man, a man utterly beyond the reach of pots of beer influence, or anything of the kind, and I ask you to read it: "July 24th, 1880. "Attending a launch at Messrs. Edwards, Milwall, "three-quarters flood, the water was very foul, and "off Cubitt Town the stench and state of the river "was very bad, a black slimy appearance being on the "water. This was the worst state I ever saw the "river in." Your Lordship knows probably that Milwall is above Greenwich, and is a short distance, not very far below Cherry Gardens. Now, I refer to other entries with regard to the year 1880. They are entries, as I say, made at the time, and this witness speaks distinctly to the horrible smells. I am reading from his answer to question 5384, where he speaks of the black slimy appearance of the water in the river, and says it was in the worst state he ever saw the river in. That is a contemporaneous remark mode at the time when he refers to what he believes to be sewage. And this I put forward as an independent corroboration of Mr. Lewis' statement, to which not a word of reference is made by my learned friend Mr. Bidder; and yet my learned friend Mr. Bidder comes in and asks you to disbelieve Mr. Lewis because he said the river at Cherry Gardens was like the river had been in 1858 higher up; he said it had been worse in 1858 than it was in 1880, and he is corroborated by an independent man.

Now, would your Lordship kindly look at the evidence of Captain Fitzgerald of the Royal Navy. Here again, my Lord, is a staff commander of the Royal Navy and harbour-master of the Central Station on the River Thames, continually up and down the river, and will your Lordship kindly look at his diary, taking first that which relates to the year 1880, which, as printed before the Commission, goes all through July 1880. It begins on page 2 from question 5505, and I will ask your Lordship to refer to the entry of the 21st of July which is at No. 5518: "River water "this day fairly clear on surface, but filthy and "stinking underneath, every steamer leaving dis-"coloured water in her wake. Immediately above "Leather Bottle Point the water was nearly black at "the last quarter flood, covering a surface of nearly "a mile." But what is of more importance for this purpose is to show your Lordship the condition of the river upon the 26th July 1880. At question 5530, this has reference to July 1880, because the diary for 1878 was handed to my learned friend Mr. Bidder,

and he is still reading on consecutively through 1880, the entry is, "At low water to-day the river from "Bugsby down was choke full of sewage." Now, does your Lordship know where Bugsby is? It is above Cherry Gardens.

(*Chairman.*) He says that is at low water, where on earth does he suggest the sewage had come from?

(*Mr. Webster.*) From the water below and from the mud. Now, Busby's Hole is endeared to me by many collisions. I speak from a large recollection of it in the Admiralty Court.

(*Mr. Michael.*) No, I beg your pardon, it is considerably below Blackwall.

(*Chairman.*) There is a Bugsby Hole somewhere.

(*Mr. Michael.*) That is exactly the point of the discharge of the West Ham sewage at low water.

(*Mr. Webster.*) Then I withdraw what I have said about Bugsby's Hole. Now these entries go from Crossness right up, and they do point to the same state of things existing far up the river and low down, namely, offensive smells given off by the mud. I thank your Lordship for the question you put to me just now, for it enables me to accentuate what I say. It is not only the surface of the water but the gases given off from the mud at the bottom of the water.

(*Chairman.*) Nothing would persuade me that Captain Fitzgerald was not endeavouring to tell us the truth, he is a man of intelligence and observation; but how on earth he could have smelt the sewage except that he might have smelt the mud banks at the side, I do not understand, and I do not understand that the witnesses do smell the mud banks at the side.

(*Mr. Webster.*) That he does?

(*Chairman.*) That anybody does.

(*Mr. Webster.*) I could call your attention to several of the witnesses who say that it is just as offensive as the water is, that it gives off gases and bubbles in the same way.

(*Sir John Coode.*) I understand your contention to be that the evolution of gas from the mud breaks up the mud and causes it to rise to the surface.

(*Mr. Webster.*) I understand that gas is given off by the mud, and I understand that there rise to the surface what are called floating gassy masses, which are in themselves offensive, and which are apparently composed of some amorphous substance, which disappears at a touch. I am obliged to my learned friend Mr. Michael for correcting me in saying that Bugsby's Hole is below Blackwall, he is quite right, but I observe at question 5527 this gentleman says that upon the 23rd July 1880, that is the day before the independent evidence from Cherry Gardens, his entry is as follows: "Water during the whole flood "heavily charged with sewage matter from side to "side, nearly black in some places, and the river, "even at high water, above Greenwich, full of sewage "and the odour disgusting."

(*Chairman.*) It is a mystery to me. I cannot understand it.

(*Mr. Webster.*) I submit to your Lordship that the way to understand it, if I may respectfully say so, is this: Nobody pretends that this takes place in winter, or that it takes place upon one single hot day, but that the comparative freedom of the last four years has been due to the very low normal temperature of the atmosphere and to the very large amount of fresh water in the river in those four years. Now, I say, if there is a hot July and some continuous hot weeks in August there is a strong smell given off from the mud, which is the result of the washing backwards and forwards of putrescible solid matter. There might be some of it in solution, that I am not chemist enough to know. May I point this out to your Lordship: Assume in the year 1880 a small amount of fresh water coming down, effect of the tide greater relatively, washing up and sending out of sewage by the Board. I do not suggest that they are doing anything wrong. I take it that they are obliged to do it, but being obliged to send it out while the tide is flowing up, the result is that you have sewage carried up 5 or 6 miles, and that sewage will deposit. Nobody imagines that that sewage goes backwards and forwards like a cork, it mixes, the specific gravity of it is altered, part of it goes to the bottom and part of it floats. I suggest to your Lordship that what this gentleman has spoken to as being the fact is in accordance with the scientific probabilities of the case; that there is this sewage washed backwards and forwards for a short time depositing its solid particles.

Now there was another witness, also of undoubted position, and making independent entries in corroboration of his evidence. I have called attention to Mr. Lewis, Captain Marsden, and Captain Fitzgerald, quite independent gentlemen in respect of their evidence being independent. I now refer to Captain James. Captain James has been harbour-master for a great many years, he begins at question 5174, he is 69 years of age and he has been upon the river 67 years, so he must have begun at two years old, but we will take him to have been 20. Now in 1880 he makes his entries in the month of July, and he is told to do it in consequence of the foul condition of the river, by a man above suspicion, and I ask you to look at the entries, take the 29th.

(*Chairman.*) Where is he the Harbour Master.

(*Mr. Webster.*) From Greenwich to London Bridge, and Captain Fitzgerald goes down thence to Greenhithe. Now I refer to Questions 5754. 5755 and 5760. At No. 5754 he is asked, "What is your entry "on the 29th of July," and he gives it as "water in "the river very black and offensive to the smell." (*Q.*) What is your entry on the 30th of July. (*A.*) "Water in the river very black and offensive," and at Question 5760, he is asked "What is your entry "on the 31st of July," and his answer was "The "water very black and offensive in the creek, as well "as in the river," that is below Deptford Dockyard, and a quarter of a mile above Greenwich. Then in the year 1881.

(*Chairman.*) Will you refer to Question No. 5756. Mr. Bidder asked the question, "Can you fix the "place" to which the witness replied, "From Green-"wich to London Bridge."

(*Mr. Webster.*) I say again it is an independent way of stating it, and I say it is one of those things your Lordship has often commented upon as an indication that the men are telling the truth. Just see what we have got. Mr. Lewis says Cherry Gardens, Captain Marsden says Millwall, Captain Fitzgerald says above Greenwich, this gentleman says Deptford Creek, and then my learned friend, Mr. Bidder interjects a question and the witness says from "Greenwich to London Bridge."

(*Chairman.*) Then at Question 5759 the witness was asked, "You are not able to specify any particular reach or anything of that sort? (*A.*) The whole of the river from London Bridge to Greenwich."

(*Mr. Webster.*) The man may not have been a very careful observer. My learned friend Mr. Bidder finds fault with him at Question 5773, because he had not any originality about his entries, but he is not the less truthful because he entered his observations in a formal manner.

(*Chairman.*) I do not doubt that he is telling the truth, but I suggest that if he has smelt it at London Bridge, he has smelt it from some other cause than sewage.

(*Mr. Webster.*) I cannot accept that.

(*Chairman.*) Nor do I positively affirm it, because it is quite certain that some sewage is carried up at times to London Bridge, because sea water will get up to Chiswick, as it has been proved.

(*Mr. Webster.*) I should agree with my learned friend Mr. Bidder, that the smell will keep in a man's nose, that his nose will carry it further than it exists, but in this case the man's district is below London Bridge.

(*Chairman.*) You are rather saying that the man's evidence is inaccurate, are you not?

(*Mr. Webster.*) No, I do not say that it is inaccurate.

11 July 1883.

(*Chairman.*) You say he carries it too far.

(*Mr. Webster.*) I say respectfully, that that is not the proper criticism to apply to the evidence. His terminus may be one that your Lordship thinks improbable, but sewage may have gone up above Greenwich. All I submit is that those are facts which he has spoken to. At Question 5787, he has spoken of from Greenwich to Limehouse, and these entries are made from time to time. My Lord, there are four of these men. I am not pausing to comment upon what I may call the smaller fish, but your Lordship will not understand me as throwing overboard or rejecting them at all. This is the character of the evidence which ought not to be mistaken. You have the entries of Limehouse and Deptford, in the witness's diary, and they are entries made at the time, it may be that he enters it formally, but your Lordship will not think the man was not entering the truth, because he was in the employment of a competent man. That the sewage can be taken high up under certain unfavourable conditions, of very little fresh water and the tide running up a very long way, the wind helping it up, and the sewers being obliged to run at a time when those who manage them, do not wish them to run, I think there can be no doubt is possible.

Now, I will refer you to Mr. Collingridge's evidence; he is the Medical Officer to the Port of London, and I would refer you first to his answer to Question 5860. "One of the witnesses told the Commission to day "that occasionally you find the water pretty clear on "the surface, but underneath of a much worse cha- "racter; as far as your experience is concerned, is "that true. (*A.*) Yes, certainly." And again, he is asked, "You have spoken of its being increased by the "stirring up of the paddles and also of the patches; "is it your view that those patches come from below "and spread over the surface," to which he replied: "I believe that the patches are caused by the in- "fluence of the tide, or some other influence bringing "up the sewage mud from the bottom of the water. "(*Q.*) How would you describe the patches. (*A.*) I "should describe them as very slightly diluted sewage. "(*Q.*) How do you judge of that? (*A.*) I have "taken specimens of these black patches and taken "them to my office in bottles and examined them. "They are very thick indeed, there is a very large "amount of suspended matter, and the smell from it "is horrible. A large quantity of the suspended matter "is pure sewage, fœcal matter. These specimens have "not been chemically examined. (*Q.*) But you have "no doubt of the correctness of your opinion that it "is sewage matter. (*A.*) I have no doubt whatever. "(*Q.*) Have you watched the stream as it flows out "from the outfalls? (*A.*) Frequently. (*Q.*) Can "that be traced for a considerable distance on the "river? (*A.*) At times. It depends very much "upon the state of the weather and upon the direction "of the wind." Then he describes the two streams and says that sometimes, "In the stream you have "these small pieces of fœcal matter which are small "as a rule, but sometimes you come upon very large "masses; you get matches, paper, and vegetable "matter, and a large quantity of corks at times." Now, my lord, it is beyond all suggestion that Mr. Collingridge should have overdrawn that picture. What I desire to impress upon your minds is, that this is a state of things, the possibility of which the board will not recognise. The board indicate by their chemical evidence that the thing cannot exist now, and they say that the action of the tide is as much as is wanted to deodorize the sewage, and that there is no necessity for anything more. I submit that the parties are not at one upon the question of fact, and that, if they were at one upon the question of fact, there would not be that divergence upon the question of chemistry, or upon the microscope. Now my point is, that this evidence comes from various independent men who have made their independent notes, and I ask you, can you not believe that, allowing for any exaggeration which you think ought to be allowed for, this does represent a very serious state of things, and a state of things which, if it can be avoided, the city of London ought to avoid?

(*Chairman.*) At Question 5,871 the witness is asked, "Can you tell the Committee how far that "stream which you say is distinguishable from the "water of the river can be traced?" and his answer was, "I have traced it downwards well into Erith "Bight" which is about three miles. I infer from that that the two streams have got by that time quite mixed, so that the one is quite indistinguishable from the other.

(*Sir John Coode.*) Each must have crossed the other by that time.

(*Mr. Webster.*) By that time you have got the two.

(*Chairman.*) There would not be any smell, there I suppose.

(*Mr. Webster.*) I do not know, that is a question of degree. I do not know whether anybody could answer that question.

(*Chairman.*) But it is of some consequence you know, because if this smell only lasted over a short space that is one thing; but if it lasted for ever, that is another.

(*Mr. Webster.*) If I was standing only upon the fishing evidence, though I submit that that is important itself, that the fish die and that the eels turn up when they get into this foul water, that the anchors are covered with a dirty and horrible black stinking incrustation of mud, that the clothes getting into the water are fouled, and that the cables and decks of vessels get dirtied, if that were the only evidence, I should ask you to hesitate seriously before you dismiss the thing as unimportant, but when I am able to point out not that one man has made a mistake, but that from independent sources the same evidence is given over the same period of time, it points to a very far larger existence of smell than a merely temporary one.

(*Chairman.*) Do you think that any ship coming up the river would pay 1*l.* to get rid of the stink.

(*Mr. Webster.*) I certainly think so, the owners of the ships would, I should say.

(*Chairman.*) 2*l.* would you say.

(*Mr. Webster.*) I am not entitled to advise your lordship as to that.

(*Chairman.*) It does not last all day.

*Mr. Webster.*) I do not admit that. I know your lordship does not put it to me as expressing a judgment upon it.

(*Chairman.*) I am merely putting it interrogatively, but I must not put the words into your mouth.

(*Mr. Webster.*) I submit that, under unfavourable circumstances it lasts very much longer than the sewer is running.

(*Chairman.*) Because there is a reservoir of deposit in the mud below.

(*Mr. Webster.*) And that, allowing for the emanation of gases, the causing of local pollution is not measured by the running in of the sewage water until it is oxidised, but that it goes very much further. Now, my Lord, I ask your Lordship to remember this, that there is a distinct admission by my learned friend Mr. Bidder, and there is the positive evidence of fisherman after fisherman, that the fish are driven below Gravesend.

(*Chairman.*) And they not only admit it, but they rely on it.

(*Mr. Webster.*) I do not regard it as an unimportant matter that the fish in the river should be utterly destroyed. I contend that it is an important matter.

(*Chairman.*) And so Mr. Bidder admitted at the outset.

(*Mr. Webster.*) No, not at the outset.

(*Chairman.*) At all events, very shortly afterwards, but he did admit that there is no fishing above Gravesend now.

(*Mr. Webster.*) He did not admit it before question 1906, when a great many fishermen had been exa-

mined. Now your Lordship is, I know, putting before me very kindly everything which is worthy of consideration. I do not admit that it is true that they have killed the fish to purify the sewage; that it is a necessary consequence, consequent upon the oxygenation going on. I did, in the earlier part of my evidence, dispute the statement that the mere oxygenating, for the purpose of getting rid of the nuisance, kills the fish. I say that it is not the oxygenation which gets rid of the fish, but that it is the polluting matter which turns them up; and I ask you not to dismiss this fish question as not being of importance in itself. I do not know whether they pretended that the other fish come above Gravesend.

(*Chairman.*) It is a mischief, and is conceded to be a mischief.

(*Professor Williamson.*) Is there any evidence which points to the fact that it is the fœtid matter in the water rather than the absence of oxygen which destroys the fish.

(*Mr. Webster.*) I do not know that there is; but I should beg to be allowed to remind the noble chairman of many fishery cases in which he has been judge in the Court of Appeal in which there has been actual polluting matter given as the cause of the death of the fish, and not the oxygenation, not that it makes much difference; but that it is an unavoidable necessity, in order to have the sewage purified, I respectfully question. Now at question 10,676, Dr. Tidy was asked by Dr. de Chaumont, "It was suggested to you in your examination that the "deficiency of oxygen in the water was one of the "causes of the death of the fish, but you did not, in "your answer, mean to imply that the fish might "not also have been poisoned directly by the water," and his answer was, "Certainly not. I do not know "as a fact to what extent the oxygen must be "deficient to prevent fish life, but I am equally "certain, first, that there may be varieties of organic "matter which may be themselves poisonous, and "secondly, I am equally certain that the formation "of sulphuretted hydrogen in the water, owing to "the action of the carbonic acid on the reduced "sulphates, would undoubtedly be poisonous to "animal life. As a fact, a very minute quantity of "sulphuretted hydrogen put into the water of an "aquarium will kill all the fish." That to a certain extent meets the point to which my attention was called, and I do not remember that there was anything else.

Would your Lordship now let me call attention to the evidence of a very different class of witnesses, and that is Captain Morrel, of the "Cornwall" and Captain Gillett of the "Warspite," which was evidence given early in the case, and this again is evidence upon a matter which I submit admits of no question. This is not a question of smells from factories. The "Cornwall" is moored at Purfleet. Your Lordship will find that having used the water for washing the decks, they discontinued it because of the stinking nature of the water that was used. Now, I do not think anybody has suggested that the smells of the factories would have got into the water so as to impregnate the water and get the smell on to the deck in that way. Your Lordship will find it at question 663, where Captain Morrel was asked, "Used you to "use it some years ago? (*A.*) Yes, for washing the "decks and for the boys bathing some times. "(*Q.*) Have you altered that practice for any reason? "(*A.*) I have discontinued it for several years. "(*Q.*) On what grounds? (*A.*) Because it used to "smell so bad that it was unhealthy. (*Q.*) What "kind of smell was it? (*A.*) A sickening smell, "arising from gases, it seemed to me. (*Q.*) Any"thing like a sewage smell? (*A.*) I can hardly tell "you that, for I have not been much in the vicinity "of sewage. (*Q.*) At any rate, you have given it "up for the purpose of washing the decks and for "bathing. (*A.*) We very seldom use it for washing "the decks; sometimes we might use it at the top "of high water for the purpose of washing the "upper deck, but never between decks, but just so "as to save fresh water." Then he is cross-examined by my learned friend Mr. Bidder, to show that at a particular period certain illnesses were not traced to the sewage; but I only remind your Lordship that in these very reports there was the fact that there was this smell of sewage, and that the water was so bad. Now Captain Gillett, of the "Warspite," which is stationed at Purfleet, below Woolwich, gave evidence, and I will refer you to his evidence; at question 803, he was asked, "Have you noticed as to whether the "water is in a pure or an impure state off your ship? "(*A.*) Just now it is very clear. (*Q.*) During the "last two or three years, can you tell us what has "been the condition of it? (*A.*) For a month in "the middle of the summer, generally in July, it has "been very bad." Now this is not a suggestion made to him. It is his own statement, "the water "becomes slate-coloured, and great masses of black "mud come up from the bottom and spread all over "the surface. (*Chairman.*) Has that been so this "summer? (*A.*) No, not this summer, yet. "(*Mr. Morice.*) But the last two or three years has "it? (*A.*) I did not notice it the first year I was "there, which was the summer of 1878, but in all "the succeeding summers it has been very bad "indeed, the smell is perfectly dreadful. (*Q.*) At "night time do you take any precaution with regard "to the ports? (*A.*) I am obliged to close all the "ports and keep the deck under the hammocks wet "with disinfectants." Now, whatever the cause may be, I submit to your Lordship that he cannot be mistaken in the fact that the smells come up over the river.

(*Chairman.*) Who is responsible for the situation of the "Warspite"?

(*Mr. Webster.*) I cannot say, but this I do point out, that the importance of it is that they have avoided the use of the water as far as they can for purposes where it might be injurious to health.

(*Chairman.*) Why on earth do not the authorities move the "Warspite" if the situation is objectionable?

(*Mr. Webster.*) I believe it is a matter which rests with the Thames Conservancy as to the point where they shall moor, so that they shall not interfere with the navigation of the river. I am informed that they shifted the "Worcester" from Erith to Greenhithe, now, would your Lordship look at question 828, where the witness was asked "And you find the sewage comes up to there" (that is Woolwich) to which the witness replies "Yes, it comes up to us, the whole "bed of the river, I believe, is covered with it, it "sinks, and when the temperature rises to a certain "point, it rises with it. It appears as if gases exploded "in the bed of the river, because it comes up and "spreads all over; it comes up in great masses of "black stuff, sometimes as big as this room." I have the impression that Professor Way gave a scientific account of something of the same kind.

Now, there are pilots, there are Custom House officers, there are policemen, there are inspectors of a superior description; there are inspectors of the Waterworks Company, men of not an ordinary description upon the river, there is the Chief Inspector of the Company, who was examined at question 3447, there are the dredger men,—in fact, I am not suggesting when I say that there are eight or ten different classes of people who speak to this thing, and who have observed it from different points of view.

(*Chairman.*) Do any of the Beckton gas people live on the other side of the river?

(*Mr. Michael.*) No, they live at Beckton.

(*Chairman.*) Have you any people who are in the habit of crossing the river?

(*Mr. Webster.*) I am told that they live at Woolwich, but I am not going to suggest—

(*Mr. Michael.*) All the Beckton gas people live at Beckton itself, as I understand.

(*Chairman.*) Is there any feeling about there?

11 July 1883.

(*Mr. Webster.*) It is at North Woolwich. Now, I do not suggest that in a normal year it will go as far up the river as in abnormal years, the year 1880 was an abnormal year, because it was very dry, and then, when an extraordinary thunder-storm came, these black masses sank to the bottom of the river. Now I refer again to the evidence of the witnesses, who have no reason for mis-representing this, and I do refer you to the answer of the sergeant of police at question 3214, which was, that in order to get rid of the dreadful smell that there was from the clothes, they were obliged to boil the clothes. That was the case of the "Princess Alice" in which some 200 odd bodies went into the river.

(*Chairman.*) Then you have the evidence of an intelligent medical man on the other side, who said that he saw no difference, but he had not the same reason for inspecting the clothes as the sergeant had.

(*Mr. Webster.*) No, he had not; he was called in just to pass the bodies.

(*Chairman.*) Besides that there is this remark, that would strike any man familiar with evidence, that one man saw it, and the other man did not, or was not asked about it.

(*Mr Webster.*) For all we know, the medical man's duty would not arise until the poor body was stripped by this man.

(*Chairman.*) No doubt both witnesses were telling the truth; the medical witness satisfied me that the people were drowned, but the other man says their clothes were offensive.

(*Mr. Webster.*) Now, I submit that that is quite abnormal, and cannot be referred to the ordinary condition of the bottom of the river. At this point I ask your Lordship to say that I have sufficiently called the attention of the Commission to the prominent leading and reliable evidence. I am not throwing overboard the other evidence at all, but it is not such evidence as I ought to occupy your Lordship's time by dealing with at length.

Now, I said that I should refer to the evidence produced by the Metropolitan Board of Works, and it is a very remarkable thing. I am not dealing with the chemical part of the evidence; but does your Lordship believe that it would not have been possible to have called persons who would have said, I have been going up and down the river for many years, and I have never seen anything like these patches. I cannot help saying that it is a fair observation, that if they could have got the evidence, they would have got it; it is an absence of evidence from people who live upon the river, which is noticeable. We have had people who have gone down for the purpose of this inquiry in years which, on all hands, are admitted to have been better years for their purpose; but it is a fact that there are only two witnesses who speak to anything connected with the water. We have had the medical men from the districts which are inhabited by what my learned friend Mr. Bazalgette has called the "riverine population," and they say that they do not think their health is affected, but they say, many of them, that they have smelt bad smells upon the river, and wondered that their health was not affected; but there are only two independent witnesses, Sir Frederick Abel and Captain Miller.

(*Chairman.*) I think Sir Frederick Abel gave evidence under a request from me.

(*Mr. Webster.*) I ask your Lordship not to take much account of Captain Miller. I cannot help thinking that the members of the Commission will have some recollection of the manner in which Captain Miller of the "Castalia" gave his evidence. I think you were not quite satisfied with the manner in which he gave his evidence. I asked him why he did not bathe when he was at Galleons Reach, and he said, "Why did I not bathe this summer in Erith Reach," not a very polite answer, and he is a master mariner, and he said that he always bathed at the top of the tide, though, when he was in a boat, he would have had no difficulty in bathing at any part of the tide.

(*Chairman.*) How could he bathe when a strong tide was running?

(*Mr. Webster.*) When he had a boat with him the boat would drift with him.

(*Chairman.*) But how do you account for his coming here to tell an untruth?

(*Mr. Webster.*) I do not say he did come here to tell an untruth; he is the one man who has not smelt it, but indeed he did smell it.

(*Chairman.*) What do you say to the medical man at Grays, who was in charge of some soldiers there?

(*Mr. Webster.*) Now, does your Lordship know that Surgeon-Major Griffiths, to whom your Lordship is referring, lives some distance from the shore below Purfleet, below the "Cornwall" considerably, and more than that, he never went there till the Autumn of 1880?

(*Chairman.*) And that there had not been a bad year since?

(*Mr. Webster.*) Not so bad a year.

(*Mr. Norman Bazalgette.*) You recollect that his garden ran down to the river.

(*Mr. Webster.*) Will you remember that he was below Purfleet?

(*Chairman.*) What I am suggesting to Mr. Webster is the case of a man who had been long upon the river.

(*Mr. Webster.*) My learned friend shall even have a reply upon me, endeavouring, if he possibly can, to point out any evidence of fact in contradiction to what I have suggested, though it is entirely unusual. I say again that they have called medical men who have been about their business, and who have come and said, no doubt the truth, when they said that they could not detect any diminution of health. No doubt their witness spoke of the health not being worse on board the "Caledonia" Hospital ship in 1859 and 1860, that being a very bad period, but I am correct in saying that Captain Miller is the only witness they have called from off the water. Now, your Lordship will observe, that Captain Miller was asked at Question 14,738, "What have you been doing there?" to which he replied, "I have been amusing myself "partly. (*Q.*) The "Castalia," being laid up, do "you remain there all day? (*A.*) Not all day. I go "on shore occasionally, amusing myself; shooting "sometimes. (*Q.*) I want to know this, have you "bathed in Galleon's Reach? (*A.*) Yes, I have, "once or twice. (*Q.*) You were there for three or "four years, why did you not bathe there more often? "(*A.*) I beg your pardon, if you will look at the "dates, seeing that I was there from 1877 to 1878, "you will find I was not there for three or four "years. (*Q.*) Did you bathe there? (*A.*) It did "not suit me to bathe there perhaps. (*Q.*) But why "did you not bathe in Galleon's Reach? (*A.*) Why "did I not bathe this summer in Erith Reach?" Then your Lordship put it to the witness. "Is it the "fact that you did not bathe there because the water "was not tempting, do you remember," and his answer was: "Not at all—by no means; if I thought I wanted "to have a swim, I should have gone in"; and then I asked him, "Do you suggest that the water in Galleon's "Reach was inviting to bathe in? (*A.*) Yes, it was. "(*Q.*) Was it just as inviting as in Erith Reach upon "the top of the tide? (*A.*) No, scarcely. (*Q.*) Why not? "(*A.*) Because there is not such a head of water "comes up there upon the top of the tide. (*Q.*) "Then the water is better in Erith Reach? (*A.*) "Yes; if you go round the river you will understand "that. (*Q.*) Erith Reach is three or four miles "further down then Galleon's Reach, is it not? (*A.*) "Yes, it is. (*Q.*) Now, you say you remember "the hot weather of 1881; how much of it was "there? (*A.*) I cannot say. (*Q.*) Was there a "week? (*A.*) I think there was more than a week. "(*Q.*) About what month was it? (*A.*) It was June "and July, I think. (*Q.*) The river began to smell "faintly, as you have said? (*A.*) Yes, it did. (*Q.*) "About how long after the hot weather began did

" the river begin to smell faintly? (*A.*) It was " smelling when the hot weather was on. (*Q.*) " What was it smelling of? (*A.*) That I cannot " say. (*Q.*) Can you describe the smell? (*A.*) " There are so many smells, I cannot pick them " out." I am justified in saying that this man (he is only one, and, therefore, the observation cannot be made against me that I am dealing with a number) may be unable to smell it; but, I have heard your Lordship say, that the evidence of a man who has smelt a smell is worth the evidence of half a dozen who say they have not. Now, I will call your attention to Question 14,763, where I asked the witness: " What I want to put to you is this—you do bathe " when you have the fullest amonnt of water up? " (*A.*) Yes. (*Q.*) Did you not know that the sewage " was let out upon the beginning of the ebb? (*A.*) " I did not know whether the sewage was let out " upon the beginning of the ebb or not." I think at the time your Lordship took the same view that I did, for you suggested to me whether I could not trust the Commission to draw their own conclusions as to this.

(*Chairman.*) I said, " The witness says, that shortly " after that he smells a strong smell, and we know " that is about the time the sewage is let out," and then I said, " Cannot you trust to us to know that " that is the time when the sewage is poured out?"

(*Mr. Webster.*) Then, my learned friend, Mr. Michael, is anxious that I should read the evidence of Mr. Griffiths. I may say, that he went to Purfleet, in November 1880; he knows nothing about the bad years before that, and he did for a long time smell a smell which he did attribute to the river, but now he does not, and he says, that the river was discoloured at the time; but now he has come to the conclusion that the smell was not attributable to the river. He is the one resident called by the other side.

Now I have finished the remarks which I have felt necessary to address to you. May I conclude by saying this. I repeat, as I said upon the very first day I came here, I am not here attacking the Metropolitan Board of Works in any way.

(*Chairman.*) Certainly not, they have succeeded to this business; there is probably not a member of it now who was in existence as a member at the first.

(*Mr. Webster.*) What the City have to do is to act as guardians of the health of the population of the City of London. They have had brought before them that this nuisance exists, as they are told, and exists to a serious extent, and they have to consider and see if this nuisance exists by solid matter in suspension being sent into the river, whether that is a proper thing to be allowed to continue. If the Commission think that there is nothing to complain of, no nuisance, then I am sure the City will be very glad that the river should have the certificate of character that your Lordship and the Commission can give it. If your Lordship and the Commission do think that that evidence which has been called by my learned friend, Mr Morice, and myself, and that evidence could have been strengthened by many more, (though I certainly do not see where the Metropolitan Board of Works could even have strengthened theirs) I ask you to report that though not perhaps now dangerous to health, it may possibly in the future, in the very hot weather, cause a serious outbreak. May I be allowed before I sit down to thank the Commission for the indulgence they have shown me in connexion with this inquiry.

(*Chairman.*) What I understand you to say is this, that the river and the mud are rendered stinking and offensive from somewhere about Deptford down to Purfleet.

(*Mr. Webster*) I think Deptford is too high as a matter of average. If your Lordship would ask me I would say, in exceptional years, as high as Deptford.

(*Chairman.*) In exceptional years as high or higher than Deptford and possibly as low as Purfleet.

(*Mr. Webster.*) Yes.

(*Chairman.*) Not during the whole course perhaps of the 24 hours, though there is no part of the 24 hours which is entirely free from it, because the gas might arise from the mud being stirred up, or from the mud flats and other things; and that this offensive smell does not arise at times, that is to say, if there is plenty of rain and fresh water it does not arise. That it is not specifically injurious to health but that it is disgusting to persons living and working upon it. That it interferes with the fishing and, I may say, even the navigation of the river.

(*Mr. Webster.*) And the enjoyment of the river.

(*Chairman.*) And that the fish are poisoned not only within the space I have mentioned but down as far as Gravesend, that is what you say that you have made out.

(*Mr. Webster.*) Yes, that is what we say that we have made out.

(*Mr. Beaumont Morice.*) My Lord, it would not have been necessary for me to say much to the Commission after the exhaustive remarks of my learned friend Mr. Webster, were it not that my learned friend Mr. Bidder, in the remarks which he has made and the evidence he has adduced, has endeavoured to show that there has been a cause of pollution by the district of Erith and that locality, especially. Now your Lordship will doubtless remember that I represent here specially what are termed Memorialists; and my Lord I have (and I believe Dr. Pole has the original here which was sent to him from the Home Office) a memorial emanating from 14,000 persons connected with the river, praying the First Lord of the Treasury to appoint a Commission in order that this matter might be investigated. Now, my Lord, there is in the schedule to that memorial a list of the members forming the general committee, and your Lordship has asked just now whether the shipowners would give anything in order to do away with the smell coming from the river. My Lord I find that amongst this general committee there are steamship companies, including the P. and O., and the British India, and all the leading steamship companies in the port of London, who have signed this memorial, together with a large number of merchants and other persons of position in the neighbourhood who have desired that something should be done in order to put an end to this complaint of the pollution of the river; so that the general character of the persons who have signed this memorial would go to show that the nuisance, as I have had occasion to mention before, is of a widespread character; and that there are therefore a large number of persons of all classes who are desirous that something should be done. Now when my learned friend Mr. Bidder in his remarks the other day referred to the evidence that had been brought forward on behalf of the Memorialists, he referred to them as an uneducated lot of persons who were giving vent to their feelings. Now perhaps that might be so if we were only dealing with the fishermen, but my learned friend, Mr. Webster, has referred to those, and I would therefore only say, seeing that there were such a number of them, not only those who were called, but of those who were in reserve, and who would have substantiated what those who were called said, that if some of them were mistaken all of them could not be.

Now, so far our evidence from being confined to fishermen, I called, as your Lordship will recollect Mr. Beadle, a resident of Erith, who has been there 35 years and employs a large number of workmen and is therefore able to speak to what has been complained of. In addition to him I called Captain Morrel, Captain Gillett, the Local Board Inspector of Erith, Mr. Carttar, the coroner, the Master of the East and West India Docks, the Inspector of the Watermen's Company, the pilots, and different sorts of people, to show the Commission that the complaint was by no means confined to one class of persons, but was generally shared in by all classes, in fact all persons having business upon the river at all are at one in this matter.

Now it would not have been right upon my part to bring before the Commission persons who, like

11 July 1883.

steamship owners, have not any direct knowledge of what they would have come to prove, but I am obliged to go to persons who have actual contact with the nuisance, with the smell, and with the mud and with the sewage deposit which exists upon the river, and for that reason I did bring undoubtedly a great number of persons who may be in the lower ranks of life, but who may be taken to be pre-eminently qualified to give evidence of value upon this question.

(*Chairman.*) Did you bring any captain of a steamboat forward?

(*Mr. Beaumont Morice.*) Yes, I did, my Lord.

(*Chairman.*) And you brought some pilots?

(*Mr. Beaumont Morice.*) Yes, I brought some pilots, and a captain of a tug also, the tug "Wildfire."

Now I would just, if your Lordship will allow me, instance the points which I think I have put before the Commission, and which I think the witnesses have proved. Now the first point has been that there has been a great alteration in the character of the water of the river, that is to say, this alteration has been fixed at a time within a short period after the opening of the outfalls, and that whereas before that there was a good deal of unpleasantness up here at Westminster and it was clear down below, the position has been altered.

(*Chairman.*) I do not think they deny that upon the other side, because confessedly the fish are killed by some condition of the water which must have been different from what it was when the fish could live there.

(*Mr. Michael.*) And whether it is brought about primarily or secondly is not of much importance.

(*Chairman.*) It is not of much importance.

(*Mr. Beaumont Morice.*) That must have been within four or five years after the opening of the outfalls, and within the last nine or ten years that condition of things has become very much worse. Now Mr. Beadle fixed that very clearly to the Commission; he said, he thought the river was not charged with sewage very much at first, but was getting worse every year. That was the evidence of other witnesses, Mr. Sandford and Captain Walter of the "Arethusa," the latter of whom said that he had been there eight years, and that the river was getting rapidly worse. So that not only have you one person stationed at one part of the river——

(*Chairman.*) I do not see how that is a physical possibility, because if it were physically possible, one would think that the river in time would become all Cray water, for example: There is a river called the Cray, that falls into it, but it does not become more Cray water than it has been in the last thousand years, and if it does not, why should it become more sewage water.

(*Mr. Beaumont Morice.*) I quite follow your Lordship, but your Lordship will allow me to say, that the sewage is very greatly increasing, and in addition to that increase there is the admitted pouring in of the sewage before high water. So that you have these two states of things, you have the additional amount of sewage in itself, and you have the probability, and the very great possibility, of a large portion of that sewage remaining in the river; a portion of it going up and next day going down. So that when you come to the evidence of Captain Gillett, you will remember that he says, he saw the sewage up there; and your Lordship noticed that remark in his evidence, where he says he always did have the sewage; that it is always present; that would be so, if he, a short space above the outfall, does have the sewage coming up with the flood, and then going back with the ebb, and if he is obliged to close the ports, and so on, he would have the sewage constantly present with him. He was asked, whether the sewage did come up as far as his vessel? and he said, No doubt it does come up, we have the sewage constantly present with us. It is because of the increasing nature of the sewage volume which is constantly put in, and the deposit that is accruing, that this state of things is stated by the witnesses to be becoming worse and worse.

Now what is also stated by the other witnesses I have called is, that the state of things in the river with regard to the condition of the water has been becoming worse and worse in recent years; and although you may get a year which is better by reason of its being cooler, and there being more fresh water in the river; yet that the general state of things is, that the river is getting rapidly worse and worse.

Now with regard to the question of fish. I mention it only for this purpose, that when my learned friend, Mr Bidder, admitted that the fish were gone, he would not accept your Lordship's remark that the fish had been poisoned, but he says, I admit that the fish are not there but I do not admit that their absence is due to the sewage outfall; and when your Lordship finally asked him if he did not admit that they were poisoined, how did he account for their going away; he declined to make any further admission except that they found that the fish were not there, that in fact it was not thought advisable to bring them through the sewage zone. Now the fact remains that the fish were there before the sewage outfall was opened, and they remained there a year or two afterwards, and that they have been gradually driven down reach by reach until they have at last got to Gravesend and places below Gravesend, where alone they can be found. Upon the point of the fish I venture to say that the evidence is conclusive.

(*Chairman.*) There is no doubt about it that they are not in the river. I think none of us have any doubt that directly or indirectly the sewage has caused the fish not to be above Gravesend. I think that is admitted.

(*Mr. Michael.*) The only difference is the word that my learned friend has put in, namely, the "outfalls."

(*Mr. Beaumont Morice.*) The next matter which my learned friend, Mr. Bidder, said had been specially put forward by the Erith witnesses was the case of the mud deposit. Now at the outset my learned friend tried to show that that was the identical matter which had been settled in the Mud Enquiry, now that is not so. Your Lordship remembers, and I think your Lordship mentioned it, upon one or two occasions, that that was a question of the navigation of the river. What the banks were composed of was very indirectly in question at all, and for my purpose it is of very small consequence what has caused these banks to accumulate in the first instance; the question is, what is their composition now; but if I can show as I think my witnesses do show, that they are composed of sewage.

(*Chairman.*) How do your witnesses prove that?

(*Mr. Beaumont Morice.*) First of all Mr. Beadle proves that it is black stinking mud different from what was there formerly. He stated that he had had a steamer sunk there, and not only had he a very great difficulty in getting his men to work in consequence of the filth but that when she came up she was covered with filth of a sewage nature. Then you were told about the causeway and how it had to be lengthened, how it was covered with slime and black mud to a very great depth on both sides of the causeway.

(*Chairman.*) Has the mud been analysed satisfactorily on either side?

(*Mr. Michael.*) Yes, microscopically and chemically.

(*Chairman.*) I know it has microscopically, but has it chemically?

(*Mr. Michael.*) Yes, it has.

(*Mr. Beaumont Morice.*) Now there was a pilot named Bushby who stated that he sometimes would sleep on shore and when he went on board in the morning he said the place was ankle deep in slush; and then he went on to say that Erith was "the essence of the jelly-bag."

(*Mr. Michael.*) Let the Commission read the question and answer No. 403 "(*Q*). Have you noticed "whether in hot weather there is any sewage depo- "sited upon the bank? (*A.*) I have not noticed

" anything that I could call sewage, it seems to be " washed up into a thick state and diluted very much " with water."

(*Chairman.*) Whose evidence is that?

(*Mr. Michael.*) This is the evidence of Mr. Beadle.

(*Mr. Beaumont Morice.*) Now, my Lord, I mentioned Captain Gillett of the "Warspite" upon the subject of the sewage deposit for this reason, that he mentioned the subject that your Lordship mentioned, namely, the sewage that he found upon his mooring-chains. He had occasion to have his moorings moved, and his attention was drawn by Mr. Wood to the chain, and he went and saw for himself that it was sewage upon it, and I believe that sewage was analysed afterwards.

Now, upon the question of deposit, you will remember the witness Michael Hind, who gave his evidence with regard to Erith Causeway in particular. Now, Michael Hind is a man who is a member of the Local Board, and has lived there nearly 50 years, and had been boating there from his boyhood, and lived upon the river. He stated that he had been upon the causeway that morning at 8 o'clock, and that it was covered with black stinking mud, and he was asked by Professor Williamson as to whether the causeway had caused the accumulation of mud; that is to say, whether the causeway was built, so that it would form a kind of breakwater, so that the mud would accumulate on one side rather than on the other; and he said, in answer to question 1208, that there was nothing of the kind, that the mud was not in any way due to the causeway, that it was on both sides; that he had tried the depth of it, and found it to be from 9 to 10 feet deep. He also told you that he was an undertaker, and that he had to do with the bodies from the "Princess Alice" and also with the bodies of the cadets of the "Worcester" some years ago before the outfall was opened when the "Worcester" was moored off Erith, and that he found the bodies from the "Princess Alice" were filthy in the last degree, while nothing more than ordinary river mud was found upon the bodies of those who were drowned from the "Worcester." Then the witness Savery, who was a custom house officer at Erith, followed in the same way; he put his scull down to see how deep it was, and he said, " the scull was only twelve feet, and we pushed it " down some five or six feet, and I have no doubt, " that had it been longer we could have gone deeper, " but, so far as we could ascertain, it seemed all to " be of the same character, black sewage smelling " material, not such as you would get from the banks " of the Thames."

(*Chairman.*) I do not know about that, because no doubt, if it had been the natural bank, it would not have been easy to get your scull down five feet deep, but supposing it had been mud washed up from the river?

(*Mr. Beaumont Morice.*) He might have been able to put his scull down, but he would not have had the black sewage smelling material. Then there are several witnesses who speak of it in very concise language. The witness Hathaway said it was black stinking stuff, he could not call it mud. The witness said, when he got the anchor up, he had to employ a man with a brush for him to sweep the chain before it came on board, because of this stuff staining the deck.

Now there is one witness whom my learned friend, Mr. Bidder, did not refer to at all; in fact, several of those witnesses he did not make any mention of. You will remember the witness Fuller, a member of the firm of G. and F. Fuller, who dredge for gravel down the river. And what did he say? He commenced in the upper part of the river, and he told the Commission how he had, or his men had, to go down the river, reach after reach; that they would stay six months in a reach, and then they would go further down, and at last they had to go to Coalhouse Point beyond Gravesend to get gravel, and only that morning he had the report that the Gravesend gravel was impregnated with sewage, and he described to the Commission how this sewage exists; that it is upon the top of the gravel; that it is from 18 inches to 2 feet thick in many parts, and that his customers would not have it in consequence of its being so impure. Then one of the members of the Commission asked him "If you go to salt water would there not " be a considerable deal of salt in the gravel that you " get," and he said, "Yes; but they prefer the salt " rather than the sewage," and he told you the different colours; that the mud was whitish at the top, whereas the sewage was of a reddish brown; and he appears to have had a good deal of experience in this matter. Then I called several of the captains of the dredgers who were actually engaged in the work, and who corroborated from their actual experience what Mr. Fuller said from his knowledge as an employer.

Now, as connected with that, there has been proved to be a very distinct smell from the mud as well as from the water. I specially ask the attention of the Commission to that, because my learned friend, Mr. Bidder, in cross-examining the witnesses as to the smell, seemed to be rather amused at the distinct way in which they described the smell. Mr. Beadle, I believe, began by stating, that it was like a closet smell. He states, that the water gives off gas; that it turns black, and that it gives off gas from bubbles, which have a disagreeable smell. Then in answer to Sir John Coode at Question 259, he says, you can see these bubbles break upon the surface of the water, and in describing the smell, he says, "It is like a " badly ventilated water-closet if you go into it in " the morning." Now Bushby, the pilot, was asked about the smell, and he says, I can only describe the river as being the largest cesspool in the world; and he told the Commission the best way to smell it. No doubt the Commission are desirous to see the Thames at the time when it is best to smell it. He said, if you leave Gravesend at five o'clock in the morning in the month of July or August, or if it is a dry season, in the beginning of September, and the water comes up and it is quite still, especially if the morning is quiet and still, you get the smell to perfection. He stated also, that in going down with vessels, he has known the mate to knock off the men from washing the decks until they had got past the sewage district, and then to recommence; because in addition to its being filthy water, it was water which stained the decks of the vessels.

Now Captain Morrel of the "Cornwall" described that as a sickening smell, and so did Captain Walter of the Royal Navy and of the "Arethusa." He described it as a sickening smell; and Captain Gillett states, that the smell is perfectly dreadful. Now if only two persons had mentioned about the cesspool smell, it might have been a matter of amusement more than anything else; but nearly all those witnesses agree in the character of the smell. Mr. Egerton, the Surveyor to the Erith Local Board, describes it as like a cesspool emptied two or three days: "It would " then smell somewhat similar to what it would if it " had not been disinfected and cleaned." He states, that his house is above the river, and that in coming down from his house of a morning, he gets into this sewage smell, and it is very difficult to get out of it; that he can get out of other smells, but not out of that smell, and if the morning is of a foggy character, he is unable to get rid of it altogether.

Now the next witness I called upon this point was Michael Hind; he went into exceeding detail about it, for he told you exactly how many days old that cesspool smell appeared to be, and he agreed as to the smell exactly, so much so that my learned friend Mr. Bidder asked him whether he had been comparing notes with the previous witness, and he said "No, if " you went to smell it you would soon see whether it " was a cesspool smell," and he said he smelt it when the wind was north-east or east. Now that is important as regards the objection which has been made

11 July 1883.

that the smell came from factories. Now a north-east wind or an east wind could not bring any smell from the factories; and the evidence of Hind is that the time when the smell is strongest at Erith is when the wind is north-east or east.

(*Chairman.*) That will be when the wind is blowing from Erith towards the sewage.

(*Mr. Beaumont Morice.*) No, from Purfleet, towards Erith.

(*Chairman.*) I remember it, but I cannot make it out, an easterly wind would come to Erith before it came to the outfall.

(*Mr. Beaumont Morice.*) Yes, certainly.

(*Chairman.*) And a north-easterly wind would blow at right angles to a line drawn from one to the other.

(*Mr. Beaumont Morice.*) Yes, from Purfleet.

(*Sir John Coode.*) You mean it would not have come from the factories.

(*Mr. Beaumont Morice.*) Yes.

(*Chairman.*) Then it must have come from the sewage after it had got below Erith.

(*Mr. Beaumont Morice.*) Yes, exactly.

(*Mr. Michael.*) No, below Purfleet.

(*Mr. Beaumont Morice.*) All the way up the Reach from Purfleet to Erith. Now, my Lord, other witnesses agreed with respect to the cesspool smell.

(*Chairman.*) Who was this man?

(*Mr. Beaumont Morice.*) He was the auctioneer.

(*Chairman.*) Probably he did not know the north from the south. I will be bound if you were to ask half a dozen people in this room you would find they did not know which way this room looked.

(*Mr. Beaumont Morice.*) However, I do not think they would make any mistake about the easterly wind. Now I will take Captain Hussey, the principal dock-master of the East and West India docks, he said his house is within 20 feet of the river, and that the stench is something awful in the summer time. Now my learned friend Mr. Bidder talks about "uneducated "persons" and "atrocious exaggeration," as he is pleased to term it, but here is a gentlemen who certainly knows something about the river and nautical matters.

(*Chairman.*) He is in a favourable situation for the West Ham sewage.

(*Mr. Beaumont Morice.*) That may be, but there is not much sewage from East Ham which I think your Lordship means.

(*Chairman.*) No, I mean the West Ham sewage which comes down the Lee.

(*Mr. Beaumont Morice.*) Now my learned friends say, This is due to your factories, and they parade out all the factories on both sides of the river. My learned friend, Mr. Bidder, actually had the boldness to tell your Lordship the other day that the witnesses who were here to speak about the smells were unable to discriminate between the smells of the river and the smells of the factories. Now if there is one thing more than another my witnesses proved, it is that they can discriminate between the smells from the factories and the smells from the river. They say we can tell when the smells from the factories are coming. We have what Sir Frederick Abel would describe as "an "educated nose" and can tell the factory smell from the sewage smell, and the sewage smell is much worse than all the others. Now Mr. Beadle began when he was cross-examined by saying, "This smell was quite "unmistakeable," and so did all the other witnesses who followed. Now I can go beyond my own witnesses, because upon this point my learned friends have very kindly furnished me with witnesses to support what mine have said. Mr. Chatterton was called, and I asked him in cross-examination whether he could tell the factory smells from the sewage smells, and he said, "I can tell the different factory smells by "putting them in groups" and in another answer at No. 13,369 he said, "I think I could tell the smell of "the sewage below the outfull from the smell of the "factories; Oh, yes, certainly I could. Sometimes "they are a little alike, but, with practice, your nose "can detect the difference." Now my contention here is, that the witnesses I called, and the inhabitants of Erith generally, have unfortunately had considerable practice with their noses in telling the difference between these smells, and therefore it is upon the strength of that, having lived in the locality for so many years, that they come here to tell your lordship what even Mr. Chatterton, with his little experience of Erith could say, namely, that they could detect the difference between the smell of the factories and the smell of the sewage.

Now what does Mr. Easton say—he comes here and complains of the drainage of Erith, and, complaining of the drainage of Erith, I asked him whether he could smell the sewage as distinct from the factories, and he stated that he could smell it. I asked him if he could distinguish between the two, and his answer was,—I do not think there is any doubt about it; and Sir John Coode will perhaps remember that he asked him specially, because he does not appear to have given a very clear answer as to whether he could distinguish the sewage as a nuisance at Erith, and his answer is, "When once "you have smelt the sewage smell and the factory "smell, there will be no doubt about it." That is exactly what I put before the Commission as what my witnesses have said; there can be no doubt about the matter to those who had had any experience at all.

But the further objection which the Metropolitan Board of Works raised to the evidence which I brought forward with regard to the factories was,—If this be so, if it is the sewage and not the factories, why have you always complained about the factories and not about the sewage? There does seem so apparent a reason why they did not do so that one hardly needs to put it forward in the ordinary way. Here is the Local Authority, having jurisdiction and power to abate the nuisance from factories within their limits, and they have taken remedies for the purpose; and you had it from the surveyor to the Local Board that, since they had used those powers the nuisance has been very much less, but they have no power over the Metropolitan Board of Works with regard to the Metropolitan outfalls, and, for that reason, it would have been useless to take any action where they could do nothing with any salutary effect.

Now my learned friends on the other side say,—Oh, we will show that the Erith sewage is the cause of all this smell. My Lord, they called, for that purpose, the surveyor. I recalled him in order that he might show to the Commission what was the exact state of the drainage of Erith, and he showed that out of 1,883 rateable houses in the parish of Erith, only 507 drained into the river. That may be the misfortune of Erith; it may be a reason why Erith should have a drainage scheme; but, for the purpose of this Commission, it is perfectly clear that they cannot cause any pollution to the river when only 507 houses drain into it. Mr. Egerton was asked what were the sewers, and he said they were 7, 9, and 6 inch pipes, and in addition to that there was a small pipe of 5 inches, beyond that there was no pipe which he, the recognised authority, knew of in the neighbourhood of Erith. Now one of the honorable Commissioners asked what became of the slops that those houses made, and he said the slops of the 507 houses go into the sewers, but not any of the others. All the others have cesspools, and therefore a large part of the parish of Erith, which he told you is a very straggling place, is drained into the cesspools, and only 507 houses are drained into the river itself. Now Mr. Chatterton, when I asked him if he was prepared to tell the Commission that those 507 houses, draining into the river, amounted to a nuisance said "Yes, "it would be a nuisance if put upon the table," he seemed at once to realize the absurdity of this assertion by at once adding "Or if you put it into this room," but when you come to contrast that with the pollution of the river by 4,000,000 people, it does seem somewhat absurd to say that the drainage of 507 houses

can cause the nuisance of which the Erith people complain. Now, at this point, they gave me Mr. Easton as a witness again. He was the engineer, and he said that the point he had to complain of with regard to Erith, was that it was not properly drained. I can quite believe, from an engineer's point of view, that a place that has 1,300 cesspools is not properly drained; but I claim him as a witness in my favour, because he went on to say that he did not know about the nuisance at Erith, and then he was asked by Sir John Coode, at Question 15,352, "Then your view is "that there is no nuisance," to which he replied, "I do not think there is a nuisance in the river "arising from sewage at all," and again, he is asked, by Sir John Coode, whether there is a nuisance in the Metropolitan or the Erith sewage, and he says "I do not think you could smell Erith sewage *qua* "sewage."

(*Mr. Michael.*) He could not smell Erith sewage in the river.

(*Mr. Beaumont Morice.*) He could not smell the Erith sewage, so that Mr. Easton's complaint of Erith as he says, is that it is not properly drained; that may be so, but how far it cause the pollution in the river is proved by Mr. Easton himself, when he says he does not know what the nuisance is that is complained of in the locality; he is there speaking of the drainage system of the place.

Now, I only want to place one other point before the Commission. Erith is a place of something like 10,000 inhabitants, and, my Lord, it does seem exceedingly strange, when I have brought before the Commission a number of witnesses who have come from that locality, and from places close by, and who have agreed in their evidence not only about the deposit of sewage mud, but about the smells due to sewage, and who have been able to distinguish between the smell of the sewage and the factories, it does seem strange that my learned friends have not been able to bring forward a single person from that locality to controvert these statements.

(*Chairman.*) They called Mr. Easton.

(*Mr. Beaumont Morice.*) He only went there on a visit.

(*Mr. Norman Bazalgette.*) His works were there, and he was there constantly, visiting his works.

(*Mr. Beaumont Morice.*) But he has not been a partner in these works for some years.

(*Mr. Michael.*) He was the engineer employed by Erith to report.

(*Mr. Beaumont Morice.*) Now all that they have brought has been Mr. Chatterton, who has been there several times last year. Now I asked Mr. Chatterton, when he came to say that there was no complaint from Erith or Erith people, how often he had been down there, and your Lordship may remember I took him from 1872 to 1882, and he told me that he had been not very often, not much, not often. And therefore, except in the year 1882, when he was making certain enquiries and soundings for the purpose of this Commission, with that exception, they have brought forward no evidence to show what is the condition of this mud. Therefore, my Lord, I do say, that having put before you a number of witnesses, and having a great many more in reserve, of different classes, who, if the Commission would wish, I could tender before you, to support what has been said already, it does seem very strange that my learned friends have not been able to bring before you any local evidence upon this question, such as you can, in cases where exaggeration has taken place, easily bring up from a district, to say either that the statements are not true, or that they have been grossly exaggerated. Now, I think when my learned friend referred to the uneducated persons who have been before you here and stated that they had made atrocious exaggerations, it would have commended itself more to your Lordship and the other members of the Commission if he had brought forward evidence to controvert what they had said, bearing in mind that those persons have agreed in the main with the evidence which has been given by other witnesses before the Commission. I now wish to thank the Commission for their kindness to me during the inquiry. I do not know whether they have decided about hearing further evidence.

(*Chairman.*) We have not.

Adjourned *sine die*.

# APPENDICES.

Being a selection from the documents submitted to the Commission.

PRINTED DOCUMENTS.


Page.

J. Extracts from correspondence received from the Home Office, July 1882 - - - - 689

K. Memorial presented to the Prime Minister - - - - - - 692

L. Letter from Captain Burstal to Sir Benjamin Hall, 18th November 1856 - - - - 694

N. Correspondence, &c. received from the Thames Conservancy Board, July 1882 - - 695

O. Reports from the Officers of the Woolwich Local Board of Health, 1878 - - - - 700

P. Extracts from Reports to the Court of Common Council of the City of London from the Port Sanitary Committee - - - - - - - 705

Q. Memorial to the Commission from the Vestry of Plumstead, 3rd November 1882 - - - 706

R. Mr. Baldwin Latham's Report on the Observations made in the River Thames, January 1883 - 706

U. Formulæ for the determination from Chlorine analyses of the ratio of the fresh-water to the sea-water in a sample of the mixture - - - - - - - 723

A.C. Table showing the result of experiments conducted by Mr. Baldwin Latham at Croydon upon the rate at which rain falls, and the extent to which the maximum fall of rain affects the flow in the sewers of Croydon - - - - - - - - - - 724

A.F. Determination of the effect of the mixing action, in the water of the River Thames, by the aid of the Chlorine test, by Wm. Pole, F.R.S., Mem. Inst. C.E. - - - - 731

A.H. Report on the suspended matter in London sewage, by Professor E. Frankland, F.R.S. - - 734

A.J. Extracts from documents in the possession of the Erith Local Board - - - 740

A.L. Gaugings of the Thames at Seething Wells, in the months of February, March, April, and May, 1882 - - - - - - - - - - 750

B.S. Extracts from Monthly Report of the Medical Officer of Health, Port of London, affecting West Ham Pumping Station in Bow Creek - - - - - - - - - 751

B.T. Return of Hand and Steam Dredging Licenses - - - - 751

C.C. List of witnesses who have not yet been called - - - - - - - 752


MAPS following page 762.


B. General map of the Main Drainage System of the Metropolis.

C.D. Sketch-map showing various points of outfall for the metropolitan sewage, proposed at different times.

C.F. Sketch-map showing the points of outfall proposed by the Government Referees, Messrs. Galton, Simpson, and Blackwell, July 1857.

# APPENDICES.

## APPENDIX J.



Extracts from Correspondence received from the Home Office, July 1882.

Guildhall, E.C.,
Sir, 19th January 1882.

The question of the pollution of the River Thames by sewage from the outfalls at Crossness and other places has recently been the subject of serious consideration by the Port of London Sanitary Committee of the Corporation; and, guided by personal inspection and the results of a careful chemical analysis of the water of the river in the localities in question, they find that without doubt the state of the river at Crossness and Barking Creek (although in consequence of constant meteorological changes it must of necessity vary from time to time) is, from the great outpouring of sewage, always in a condition most unsanitary, exercising, in periods of drought and great heat, very prejudicial effects upon the public health; and bearing in mind the fact that the quantity of sewage has of late years enormously increased and is constantly increasing, the Committee feel that the time has arrived when some decisive action should be taken in the matter, and they therefore deem it expedient to take the step which, under the Metropolis Local Management Act, 1858, cap. 104, sec. 31, is open for adoption, and I am therefore instructed to urge upon you the extreme importance of immediate steps being taken towards remedying that which must be admitted to be a great and growing evil.

I have, &c.,
(Signed) John B. Monckton.

To the Right Hon.
Sir W. Vernon Harcourt, M.P.,
Secretary of State for the
Home Department.

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Metropolis Local Management Act Amendment,
21 & 22 Vict. cap. 104.

S. 31. It shall be lawful for one of Her Majesty's Principal Secretaries of State, at his discretion, on representation or complaint made to him of any nuisance committed in execution of any works, or in deodorizing any sewage, or in disposing of any sewage or refuse from sewers, or in any other manner under this Act, to cause inquiry to be made into the matter represented or complained of to him, and to direct such prosecution or prosecutions, or to take such other proceedings, as he may think fit, in order to ensure the prevention or abatement of such nuisance as aforesaid.

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14 Berkeley Square, W.,
21st January 1882.

Dear Sir William Harcourt,

The Woolwich Local Board of Health, who have passed a resolution of which I enclose a copy, wish me to ask you to be good enough to receive a deputation from them on the subject of the said resolution.

If convenient to you to do so, I should be glad to know what day in the early part of next month would best suit.

Yours faithfully,
(Signed) T. W. Boord.

The Right Hon.
Sir W. V. Harcourt, M.P.,
&c. &c.

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Copy of Resolution passed by the Woolwich Local Board of Health.

That an application be made to the Secretary of State for the Home Department to receive a deputation from this Board upon the subject of the pollution of the Thames by the discharge of Metropolitan sewage into the same, and to seek the help of the Government that the present nuisance, caused by the discharge of the sewage, may be abolished as soon as possible, the same being considered detrimental to the health and comfort of the inhabitants of the town, the workmen in the Government establishments, and the troops in garrison.

Also to draw his attention to the proposed enlargement of the sewage works in this and the neighbouring parishes, which is not for the purpose of the utilization of the sewage, but for the continuance of the present wasteful and unsanitary system.

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Guildhall, E.C.,
Sir, 7th February 1882.

I have had an opportunity to-day of laying your letter of the 4th instant (A. 12786) before the Port of London Sanitary Committee, by whom I am instructed to lose no time in sending you, for the information of the Home Secretary, the enclosed report,* which will, it is thought, afford the fullest information on the very important subject it deals with. If the Home Secretary thinks I can in any way usefully supplement this, I shall be glad to do so.

I have, &c.,
(Signed) John B. Monckton.

To Godfrey Lushington, Esq.
Home Office, Whitehall, S.W.

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Local Government Board,
Whitehall, S.W.,
Sir, 9th February 1882.

I am directed by the President of the Local Government Board to state, for the information of Secretary Sir William Harcourt, that in September last the Board were furnished with a copy of a resolution passed by the Vestry of Plumstead with regard to the pollution of the River Thames by sewage from the works executed under the Metropolis Local Management Acts, and in which the Vestry expressed an earnest hope that the Board would concert measures to remedy the evil. A short time previously the Board's attention had been drawn to the alleged nuisance created by the works in question by an influential and representative deputation from the locality.

The Board have been in communication with the Conservators of the River and the Port Sanitary Authority of London on the subject, both of which authorities express their sense of a serious contamination of the river from the source referred to; and the Board learn from a letter addressed to them by the Port Sanitary Authority on the 19th ultimo that a

* Reports by the surveyor and analyst to the Woolwich Board of Health, 22nd October 1878.

APP. J.

representation has been made to the Secretary of State in the matter.

The President will be glad to be informed whether it is proposed to take any action in this matter under section 31 of the Metropolis Local Management Act, 1858.

I am, &c.,
(Signed) JOHN LAMBERT,
Secretary.

To the
Under Secretary of State,
Home Office,
Whitehall, S.W.

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Army and Navy Club,
Pall Mall, S.W.,
15th February 1882.

SIR,

I AM gratified to observe from the reports in the newspapers of the statements you made to the deputation from Woolwich as to the pollution of the Thames, that it has not escaped your memory that you assisted as counsel my late relative Mr. Napier and myself in obtaining in 1865 an Act to authorise the carrying out of our scheme for freeing the Thames from the "sewage of the northern area of the Metropolis."

It will also probably be in your recollection that the scheme had been originally presented by us to the Metropolitan Board of Works in 1861, and that during that period of four years it was not only exhaustively inquired into by the Board, but also twice, namely in 1862 and 1864, by the House of Commons.

You will also doubtless recollect the severe fight we had in committee, and the influential opposition which the bill met with in some quarters, but that eventually, the scheme being thoroughly sound, the bill passed triumphantly through both Houses.

But the subsequent history of the scheme is probably quite unknown to you; and in the belief that the fact may be of interest and even of use to you at the present moment, I have the honor to inform you that, owing to the arrangements which I made after the passing of the Act in 1865, and which were embodied in a deed (under seal and therefore binding for 20 years), the whole of the money is, if the Metropolitan Board will only do their duty to their constituents and the public at large by enforcing the deed, *already provided* for diverting the northern and most offensive as well as vuluminous portion of the sewage for ever from the Thames without expense, and even with profit to the ratepayers.

Perhaps you will allow me to add that if at any time you desire my assistance in the matter, I myself and all my papers and information are, most unreservedly, at your absolute disposal.

I have, &c.,
(Signed) W. HOPE.

The Right Hon.
Sir W. Vernon Harcourt, M.P.,
Her Majesty's Principal
Secretary of State
for Home Affairs,
&c. &c.

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Metropolitan Board of Works,
Spring Gardens, S.W.,
6th March 1882.

SIR,

REFERRING to the letter adressed by direction of the Secretary of State to this Board on the 10th instant (No. A. $\frac{12786}{3}$) with a copy of a communication from the town clerk of London as to nuisance alleged to be committed in the disposing of the sewage of the Metropolis at the outfalls at Crossness and Barking Creek, I am directed by the Works and General Purposes Committee, to whom the same has been referred, to acquaint you, for the information of the Secretary of State, that they have considered it desirable to remit the matter to a sub-commitee for inquiry, and that upon their report being presented a reply will be sent with as little delay as possible.

I am, &c.,
(Signed) J. E. WAKEFIELD,
Clerk of the Board.

The Under Secretary
of State for the
Home Department,
Home Office,
Whitehall, S.W.

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Guildhall, E.C.,
29th March 1882.

SIR,

*Pollution of the River Thames by Sewage.*

REFERRING to your communication to me of the 10th ultimo (A. 12,786) in which you state that the representation of the Corporation made to you in my letter of the 19th January last, and also the report of the Port of London Sanitary Committee transmitted to you by me at your request on the 7th ultimo have been referred to the Metropolitan Board of Works for their observations thereon, I shall be glad to know, for the information of the Committee, who meet on Tuesday next, whether you will now take action in the matter as contemplated by the statute.

I may state that considerable anxiety prevails on the subject in the neighbouring parishes.

I am, &c.,
(Signed) JOHN B. MONCKTON.

To the Secretary of State,
for the Home Department,
Whitehall, S.W.

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Metropolitan Board of Works,
Spring Gardens, S.W.,
4th April 1882.

SIR,

I HAVE to acknowledge the receipt of your letter of the 31st ultimo, forwarding a copy of a letter from the town clerk of London, asking whether the Secretary of State will take action upon the representation made to him by the Port of London Sanitary Committee, a copy of which you sent to the Board on the 10th February last.

The representation is to the effect that the discharge of sewage into the Thames from the Metropolitan outfalls is productive of injury to the public health, and the Secretary of State is asked to take the action prescribed by the 31st section of the Act of 1858, known as the Main Drainage Act, that is to say, to cause inquiry to be made, and to take such other proceedings as he may think fit.

The Board is not yet in a position to make a complete reply to the Secretary of State on the allegations put forward by the Port of London Sanitary Committee. It would wish to continue the investigations it is now making during the time when hot weather prevails, and when the state of the river is alleged to be at its worst. So far as the Board's recent examinations have gone, however, they point to the same result as has followed on all previous investigations, that is to say, that the statements with respect to the polluted condition of the river and the effect on the public health are, if not totally unfounded, greatly exaggerated.

That the water of the Thames is not so pure as could be wished may be admitted without hesitation, but there are other sources of pollution than the Metropolitan sewage outfalls, which would go far to account for the conditions which give rise to complaint.

The Board confidently expects that the further information to be obtained will but confirm the view which at present the Board has every reason to hold, that the sewage outfalls cannot be charged with such a pollution of the Thames as to cause serious nuisance or any injury to public health.

(Signed) J. E. WAKEFIELD,
Clerk of the Board.

The Under Secretary
of State for the
Home Department.

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Local Government Board,
Whitehall, S.W.,
22nd May 1882.

SIR,

I AM directed by the Local Government Board to acknowledge the receipt of your letter of the 15th instant, No. A. $\frac{12786}{17^{a}}$, and to state that they have perused the papers forwarded therewith in relation to the application which has been made to Secretary Sir William Harcourt for an inquiry under sec. 31 of the Act 21 & 22 Victoria, cap. 104, with regard to the alleged nuisance caused by the discharge of sewage into the River Thames at Crossness and Barking Creek.

As regards the suggested postponement of the inquiry, I am directed to state that as the condition of the Thames at the outfall of the Metropolitan Board

of Works has been so often the subject of complaint, it seems to the Board impossible to avoid an investigation into the question; and if a commission is to be appointed for this purpose the Board consider it very important that they should be in a position to ascertain the actual state of the river during the summer months, when nuisance is most likely to arise.

The officers of the Metropolitan Board of Works have been persistent in the denial of the existence of any serious nuisance at the outfall, and for this reason the Board think it is essential that the inquiry should not be postponed until a date when the Commission will not be able to satisfy themselves by personal observation of the effect produced by the outfall works during the hot weather, but be compelled to rely exclusively upon the evidence of others.

The papers above referred to are returned herewith.

I am, &c.,
(Signed) JOHN LAMBERT,
Secretary.

The Under Secretary of State,
&c. &c. &c.
Home Office,
Whitehall, S.W.

---

Metropolitan Board of Works,
Spring Gardens, S.W.,
5th May 1882.

SIR,

REFERRING to Mr. Lushington's letter of the 19th April, in which he requests that the Board will give the Secretary of State a definite answer within a fortnight with respect to the alleged pollution of the river Thames by the sewage from the Metropolitan outfalls, I am to state that the Board still thinks some further delay desirable to enable it to continue through the summer months, when the process of decomposition is more rapid, the tests of the condition of the water, as unless this be done it may be alleged that the Board's tests do not fairly represent the condition of the river.

The memorandum of tests forwarded by the Home Office consists of extracts from various newspapers, commencing with one from the "Times" of October 24th, 1878, which records the opinion of the officers of the Woolwich Local Board that the passengers of the "Princess Alice" who were drowned were caused to vomit by the intolerably nauseous smells and state of the water.

In support of this allegation the quantity of organic matter in various samples of river water is quoted, as affording evidence of the presence of sewage. One sample was taken 50 feet from the northern outfall sewer whilst the sewage was running out of it, and another 20 feet from the southern outfall whilst it was also discharging, and the remark is made that the water was of a very offensive character. A report was made by the Board's consulting chemist in answer to these and other similar allegations, and a copy of this I am directed to forward for the Secretary of State's information. Subsequently by direction of the Board samples of the water were taken at various points from London Bridge to Erith, and the bed of the river near where the "Princess Alice" sank was examined and found to consist of clean gravel. Several persons drank of the water and found it free from taste or smell, the tide at the time being in the same condition as it was when the "Princess Alice" was wrecked.

It would not be possible in the short time named by the Secretary of State to answer the allegations contained in the memorandum *seriatim*. But many of them, particularly those relating to the quantity of sewage discharged from the outfalls and its relation to the volume of the tidal water, were answered in the course of the enquiry held before Sir Charles Hartley, Sir Frederick Bramwell, and Captain Galton on the alleged silting up of the Thames. The evidence then given, which has been printed by order of the House of Commons, is worthy of the attention of the Home Secretary.

I am further to state that the Board, guided by the opinions of men of science whom it has consulted, denies the allegations as set out in the memorial and memorandum forwarded to him.

Another fact of which the Secretary of State should be informed is, that the enlargement of the reservoir works at the outfalls which the Board proposes to carry out will have the effect of more completely confining the discharge of sewage to the period of the ebb tide, when it becomes so diluted by the immense volume of tidal water before it reaches any place where the banks are inhabited, that its presence in the water ceases to be capable of being detected by ordinary observation.

To prevent the flow of the rain water falling upon the Metropolis from flowing into the Thames is impracticable. To separate it from the sewage would involve the re-draining of every house in London, and the construction of new sewers in every street; pumping establishments would also have to be erected in various parts of the Metropolis; and to attempt to deodorise the sewage at the outfalls by any known process would involve a wasteful expenditure, and be accompanied by serious objections, without producing adequate advantages.

The Board is still of opinion that it would greatly aid the more complete investigation of the subject, if any inquiry which may be determined upon could be postponed until the month of October, so that samples might be taken from the river during the hot months of July and August; and the Board again submits this suggestion for the consideration of the Secretary of State.

I am, &c.,
(Signed) J. E. WAKEFIELD,
Clerk of the Board.

The Under Secretary of State for the Home Department,
Whitehall.

---

Whitehall,
25th May 1882.

SIR,

I AM directed by Secretary Sir William Vernon Harcourt to acknowledge the receipt of your letter and enclosure of the 5th instant, submitting, in behalf of the Metropolitan Board of Works, their denial of the allegations brought by the Corporation of London before him of an extensive and dangerous pollution of the water of the River Thames by the discharge of sewage from the Metropolitan main drainage system at Crossness and Barking Creek, and urging that if it is decided to direct an inquiry into the correctness of the allegations, it would be more likely to obtain fair results by being postponed until October next, and not made in the hot summer months when the decomposition is more rapid.

And I am to acquaint you, for the information of your Board, that Sir William Harcourt has considered the question carefully, and has arrived at the conclusion that, in the public interests, and in view of the numerous complaints publicly made on the same subject, it is clearly desirable that an inquiry should be held in pursuance of section 31 of the Act 21 & 22 Vict. c. 104, into the matter of the aforesaid complaint of the Corporation of London, and further that it would not be expedient that such inquiry should be postponed until a date when the Commissioners will not be able to satisfy themselves by personal observation of the effect produced at the outfall works during the hot weather, but be compelled to rely exclusively upon the evidence of others.

Under these circumstances Sir William Harcourt will shortly proceed to take the necessary steps for the appointment of a small commission to conduct the proposed inquiry, and he will cause a further communication to be adressed to your Board when the requisite preliminaries have been settled.

I am, &c.,

The Clerk to the
Metropolitan Board of Works.

App. K.

# APPENDIX K.

## Memorial presented to the Prime Minister.

To the Right Honourable William Ewart Gladstone, M.P., P.C., First Lord of the Treasury and Chancellor of the Exchequer, Elder Brother of the Trinity House.

The Memorial of the principal merchants, traders, and shipowners, and the representatives of the dock, wharf, and shipping interest on the River Thames, the owners of barges and the steam vessels engaged in the passenger traffic of that river, associated together and forming a general Committee for the protection of the Lower Thames from sewage, and whose names and descriptions are printed in the schedule attached to this Memorial.

Sheweth—

That at a general meeting of your memorialists, held on Tuesday, the 7th day of March last, the following resolutions were passed:—

1. That in the opinion of this Committee a Royal Commission should be appointed, or a parliamentary inquiry instituted, for the investigation of the present state of pollution of the River Thames from sewage, and the means to be taken to remedy this alarming and growing evil.

2. That an Executive Committee be now appointed and requested to take all necessary steps to give effect to the first resolution, and to adopt such other measures as may appear to them desirable in furtherance of the object in view.

That in pursuance of the last of the foregoing resolutions an Executive Committee, consisting of four members of the House of Commons and 22 gentlemen selected from the General Committee, was at the same meeting duly appointed for the purpose of giving effect to the said resolutions.

That in August last a petition complaining of the pollution of the River Thames from sewage was presented to the House of Commons by your memorialists and other persons to the number of 13,500 resident on the banks of the river, or connected with its trade, and praying for the adoption of measures to relieve the river of the sewage, but no action was taken thereupon in consequence of the late period of the session at which the petition was presented. The following is an abstract of the signatures to the petition:—

| | |
|---|---|
| Employés | 6,696 |
| Clerks and foremen | 669 |
| Professional and medical gentlemen | 127 |
| Baronet | 1 |
| Officers of army | 26 |
| Pilots | 52 |
| Merchants, tradesmen, gentlemen | 2,537 |
| Seamen | 937 |
| Lightermen and bargemen | 1,098 |
| Captains and officers of vessels | 482 |
| Officials of local boards | 45 |
| Schoolmasters | 48 |
| Watermen | 419 |
| Ship and barge owners | 93 |
| Fishermen | 121 |
| Wharfingers | 12 |
| Ship brokers | 17 |
| Insurance brokers | 18 |
| Stock brokers | 9 |
| Underwriters, Lloyd's | 31 |
| | 13,438 |

That "The Metropolis Local Management Act, 1858," which authorises the discharge of the Metropolitan Sewage at Barking and Crossness, was passed, as your memorialists are informed, under the belief, first, that the sewage discharged would not increase to the enormous extent it has done. Secondly, that the sewage would be deodorized before its discharge into the river, and thirdly, that the action of the tide in the river would have the effect of carrying the sewage water or matter into the sea instead of its remaining in the river, as is now the case, and being carried up and down between Gravesend and Blackwall, or points higher up the stream.

That the following statement shows the increase which has taken place between 1869 and 1878 in the quantity of sewage discharged at Barking and Crossness.

Sewage discharged at the Outfalls during Ten Years, 1869 to 1878 inclusive.

| Rainfall in Inches as observed at Crossness. | Year. | Gallons per Year. | | Remarks. |
|---|---|---|---|---|
| | | Crossness. | Barking Creek. | |
| 27·93 | 1869 | 17,574,292,274 | 12,793,513,197 | Low Level not completed. |
| 18·80 | 1870 | 16,678,226,567 | 14,633,751,920 | |
| 26·44 | 1871 | 18,497,165,385 | 20,112,148,713 | |
| 32·88 | 1872 | 22,281,418,356 | 23,137,747,554 | |
| 24·31 | 1873 | 21,878,839,124 | 22,680,778,594 | |
| 24·12 | 1874 | 20,544,185,537 | 22,610,777,770 | |
| 29·28 | 1875 | 23,505,775,239 | 26,955,262,659 | |
| 28·90 | 1876 | 22,370,124,831 | 27,951,403,034 | Western Pumping Station completed. |
| 29·26 | 1877 | 26,008,009,706 | 29,995,714,676 | |
| 29·26 | 1878 | 27,317,822,594 | 30,177,765,147 | |
| 271·27 | Ten years | 216,655,859,613 | 230,849,163,264 | |
| 27·1 | Average per year. | 21,665,585,961 | 23,084,916,326 | |
| Average per diem | | 59,357,769 | 63,246,346 | |
| Together | | 122,604,115=19,679,633 c. ft. | | |

That from the above statement it appears that in the 10 years ending 1878, with a practically uniform rainfall, the amount of sewage increased by about 89 per cent., and that the average daily flow in 1878 was 157,522,157 gallons, or 25,284,450 cubic feet, representing considerably over half a million tons of sewage.

That applying the ratio of increase during the last four of the said 10 years (14 per cent.) the quantity of sewage now being discharged into the river every 24 hours from the Crossness and Barking Outfalls is estimated at 180,000,000 gallons, or 30,000,000 cubic feet.

That "The Metropolis Local Management Act, 1858," contained provisions to the effect (sec. 23) that the Metropolitan Board of Works should, until its works required by that Act were completed, make use of proper means for deodorizing the sewage, or otherwise protecting the public health from any injurious consequences therefrom, and (sec. 24) that the said Metropolitan Board should cause the works to be executed under the Act, to be constructed and kept so as not to be a nuisance, and in deodorizing any sewage, and in disposing of any sewage or refuse from sewers, should not create a nuisance.

That although the said 23rd section may be construed as having application only to the period during which the works under the Act were in course of construction, the spirit and contention of the said 24th section is obviously to prevent the nuisance now complained of, although according to the legal construction of the words of the said section it does not supply the means of enforcing such intention.

That although Section 31 of the said Act empowers one of Her Majesty's Principal Secretaries of State to cause inquiry to be made into any complaints of any nuisance committed in respect of any of the matters referred to in Section 24, and to take steps to prevent or abate the nuisance, yet these provisions, your Memorialists are advised, would not permit of an inquiry as to whether the Act of Parliament which at present authorises the outfall of the sewage into the Thames at Crossness and Barking should not be repealed, and the sewage required to be carried to a point lower down the Thames, or to be deodorised and the effluent water alone be allowed to pass into the river.

That an application made under the 31st Section of the said Act to Her Majesty's Secretary of State for the Home Department by the Corporation of London, on the subject of the pollution of the Thames, has only led to the reference of such application to the Metropolitan Board of Works, aan thus the important subject is referred back to the authority of whose action your Memorialists now complain, and your Memorialists are afraid that no good will result therefrom, inasmuch as the Metropolitan Board of Works contend that no nuisance is created by means of their outfalls of sewage, and also for the reason that the question which your Memorialists require to be investigated is not within the legal construction of the said section.

That the Conservators of the River Thames have no jurisdiction upon questions of the pollution of water in the river caused by the outfalls or works of the Metropolitan Board of Works, such outfalls and works being specially exempted from the operation of the Rivers Pollution Act, 1876.

That in the year 1879 the Conservators, in an arbitration between them and the Metropolitan Board of Works, under the "Thames Navigation Act, 1870," endeavoured, but in vain, to raise the question of the pollution of the river from sewage, but they were met with the objection that the Act applied only to obstruction of navigation of the river, and the award in such arbitration, dated 24th April 1880, contained the following recital:—

> That, having regard to the powers conferred on us (meaning thereby the arbitrators) by the aforesaid Act of 1870, the said inquiry and our said report should be entirely confined to the consideration of the origin of the said three banks and as to their being obstructions to the navigation of the said river, and that the pollution of the said river by the flow of sewage at the outfalls as a sanitary question should not be gone into or considered by us in making our report.

That the Metropolitan Board contemplates an immediate further expenditure of 164,000*l.* for enlarging the outfalls at Crossness and Barking, which will not remedy the evil, and this outlay will be thrown away if, as the result of an independent inquiry, the necessity for the extension of the sewers to points nearer the mouth of the river be proved, or an effective system of deodorization determined upon.

That the magnitude of the evil complained of is one which requires immediate redress.

Your Memorialists therefore humbly pray—

> That Her Majesty's Government will be pleased to advise Her Majesty to grant a Royal Commission to inquire into and ascertain the present state of the River Thames as affected by the discharge of sewage into its stream and the effect thereof upon the lives and health of those of Her Majesty's subjects who live or have business on its banks, or who have to navigate the same, whether in vessels belonging to Her Majesty's subjects or to foreigners, and to advise as to the best means of putting a stop to a growing evil which seriously threatens the continued prosperity of the port of London.

And your Memorialists will ever pray, &c.

On behalf of your Memorialists,

(Signed) James Edwin Thorold Rogers,
Chairman of the Meeting of the General Committee, and Chairman of the Executive Committee.

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The Schedule above referred to.

The names of the gentlemen and firms who have agreed in writing to form the General Committee for the Protection of the Lower Thames from sewage.

Captain J. E. F. Aylmer, M.P. for Maidstone.
Thos. Wm. Boord, Esq., M.P. for Greenwich.
Jas. Bryce. Esq., M.P. for Tower Hamlets.
Baron Henry de Worms, M.P. for Greenwich.
Arthur Cohen, Q.C., M.P. for Southwark, 6, Holland Park, W.
Aldermen Wm. Jas. R. Cotton, M.P. for London.
R. N. Fowler, Esq., M.P. for London.
Lord Geo. Hamilton, M.P. for Middlesex.
The Right Honourable J. G. Hubbard, M.P. for London.
The Right Honourable Viscount Lewisham, M.P. for West Kent.
Sir Chas. Mills, Bart., M.P. for West Kent.
Chas. J. Ritchie, Esq., M.P. for the Tower Hamlets.
Professor Jas. E. T. Rogers, M.P. for Southwark.
Sir Sidney Waterlow, M.P. for Gravesend.
Lord Henry Lennox, M.P. for Chichester.
John Orrell Lever, M.P. for Galway.

Anderson, Brothers, Merchants, 16, Philpot Lane, E.C.
Anderson, W., Chairman Local Board, Erith.
Armstrong, J. C., Mayor of Gravesend.
Anderson, Anderson, and Co., Orient Steam Navigation Company, 13, Fenchurch Avenue, E.C.
Adamson and Ronaldson, Shipowners, 34, Leadenhall Street, E.C.
Arnold, G. E., Wharfinger, &c., Woolwich.
Asser, Robert V., Belvedere Park, Kent.
Bennoch, Francis, Director, London Steamboat Company, Member Conservancy Board, &c.
Beale, Charles, Erith.
Bradn, Frederick, Crosby Row, Borough, S.E.
Bellamy and Co., King and Queen Granaries, Rotherhithe Street, S.E., and 6a, Fenchurch Buildings, E.C.
Boulcott, J. and Co., Limehouse.
Beck and Pollitzer, Wharfingers, Upper Thames Street.
Brown, Jas. and Alexr., Shipowners, &c., 9 and 11, Fenchurch Avenue.
Baxter, F., Manager, South-eastern Bonded Warehouses and Wharf Co., Southwark.
Bernays, Herbert L., M.R.C.S., Medical Officer of Health, Charlton.
British India Steam Navigation Company, Limited, per P. Macnaughtan, Esq., Secretary, 13, Austin Friars, E.C.
Cape, George Augustus, Chairman School Board, Erith.
Chaytor, D. A., Coal Factor, 155, Fenchurch Street, E.C.
Chambers, Brothers, 40, Seething Lane, E.C.
Churchill and Sim, 29, Clement's Lane.
Corner, F. M., Medical Officer of Health, Poplar.
Clarke, Stephenson, and Co., Shipowners, &c., 4, St. Dunstan's Alley, E.C.
Collingridge, William, Medical Officer of Health, Port of London.
Cunis, W. R., Lighterman, Lambeth.
Corfield, W. H., M.D., Medical Officer of Health, St. George's, Hanover Square.
Crook, John Evelyn, M.D., Medical Officer of Health, Northfleet.
Cousens, John S., Wharfinger, &c. Millwall Docks, E.
Corbet, R., Medical Officer of Health, Orsett, Essex.
Collier, W. E., Medical Officer of Health, Fulham District.
Chapman, F. W., 46, Gedling Street, Dockhead, E.C.
Dinham, C., Shipowner, Coal Exchange.
Denny, Thomas R., Old Corn Exchange, Mark Lane, E.C.
Deacon, H. T., Lighterman, Limehouse.
Ducas, Thomas, Lighterman, 241, East India Road, Poplar.
Fisher, Wm. Alexr. Fisher's Sufferance Wharf, Rotherhithe Street, S.E.
Fortescue, N., Bridge Wharf, Blackfriars.
Fitzgerald, E. G., Timber Merchant, Lambeth.
Fuller, Geo. F., Lion Wharf, Millwall, and North Woolwich, E.
Fishbourne, E. G., Admiral, 26, Hogarth Road, S.W.
Gosman and Smith, 150, Leadenhall Street, E.C.
Gillett, Captn., "Warspite" Training Ship, Charlton.
Greig, H. A., 2, Crosby Square, E.C., and Belvedere.
Gardner, Thos., Commercial Wharf, Mile End Road.
Gregory, Frederick, 60, Mark Lane, E.C.
Girdwood, Alexr., 50, Mark Lane, E.C.
Green, F. and Co., Shipowners, 13, Fenchurch Avenue.
Gray, Dawes, and Co., 13, Austin Friars, E.C.
Galbraith, Pembroke, and Co., 8, Austin Friars, E.C.
Gellatly, Hankey, Sewell, and Co., 109, Leadenhall Street, E.C.
Glover Brothers, 88, Bishopsgate Street, Within, E.C.
Gripper, Edwd. and Sons, Wharfingers, Southwark.
Gramshaw, J. H., M.D., Medical Officer of Health, Gravesend.
Hinton, William, Master of Waterman's Company.
Hussey, Captain, Principal Dock Master, West India Docks.
Huntley, W. R., Shipowner, Greenwich.
Hayward, J. C., Dartford.
Holland, J., Coal Factor, Coal Exchange.
Harris, Bros. and Co., 6, Crosby Square.
Hewitt and Co., 43, Trinity Square.
Harris and Dixon, Shipowners, London.
Harris, Fredk. W., 9, Chelsea Embankment.
Henderson, Bros., "Anchor Line," 18, Leadenhall Street.
Hanson, R., Alderman and Sheriff, 47, Botolph Lane, E.C.
Houlder, Brothers and Co., Shipowners, 146, Leadenhall Street, E.C.
Holmon and Sons, John, Shipowners, St. Mary Axe.
Holdsworth, J. J., Shipowner, 8, Hart Street, Mark Lane.
Hammond, Francis, Lighterman, 12, Harp Lane, E.C.
Hemmings, Jabez, Lighterman, &c., Rotherhithe, S.E.
Huddart, D., Medical Officer of Health, Greenhithe.
Jessett, F. B., Medical Officer of Health, Erith.

App. K.

Kidd, S. and Co., Isleworth, Middlesex, Princes Wharf, Commercial Road, Lambeth.
Keep, Alfred H., Lighterman, Lower Thames Street and Greenhithe.
Longstaff, John, Coal Merchant, Rotherhithe.
Lambert, R. N., Ship Owner, 85, Gracechurch Street.
Lambert, F. D., Ship Owner, 85, Gracechurch Street.
Lockett and Judkins, Ship Owners, Upper Thames Street.
Lee, William, Son and Co., Blackfriars.
Lacy, J. W., Lighterman, Rotherhithe, S.E.
Lee, J. D., Belvedere Park, Kent.
Morrell, Capt., R. N., "Cornwall" Training Ship, Purfleet.
Milnes, C. S., Ship Owner, Coal Exchange.
Murrell, Wm. Chas., Ship Owner, 16, Dockhead, S.E.
Mongredien, Ellerby and Co., 15, Leadenhall Street.
Mumford, S. P. and C., Steam Mills, Greenwich. 59, New Corn Exchange, Mark Lane, E.C.
Matthes and Co., 36, Crutched Friars.
Macgregor, Gow, and Co., "Glen Line," 4, Lime Street, E.C.
Merry, Wm. L., Wharfinger, &c. Milwall Docks, E.
Nettlingham, F. B., Ex-Mayor of Gravesend.
National Line of Steamers, Leadenhall Street.
Norris and Joyner, "Japan Line," 126, Bishopsgate Street Within, E.C.
Oliver and Co., Wharfingers, Wapping.
Pelly, Capt., R.N., Chairman, London Steamboat Company, Elder Brother, Trinity House.
Pope, Horace, Coal Factor, Coal Exchange.
Page, Samuel, and Son, 16, Water Lane, E.C.
Peninsular and Oriental Steam Navigation Company, The, by Thomas Sutherland, Esq., Chairman.
Perkins and Homer, Lightermen, 13, Water Lane, E.C.
Phillips and Graves, Messrs., St. Dunstan's House, Cross Lane, E.C.
Pinkey, Sons, and Clare, Messrs., Great St. Helens, E.C.
Parish, Fredk., Ballast Wharves, Erith.
Russell, John, Member of the Corporation, Gravesend.
Roberts, B., Lee Mouth Wharf, Poplar.
Rolt, Peter, and Co., Acorn Wharf, Rotherhithe.
Rickett, Smith, and Co., Coal Exchange.
Rowland, John, M.D., Medical Officer of Health, Richmond.
Reading and Palmer, Lightermen, &c., Waterloo Mills, Blackfriars.
Russell, George, Plumstead, Kent.
Rogers, G. A., Medical Officer of Health, Limehouse District.
Stone, H. Palmer, Director, London Steamboat Company.
Sturdy, Bros., and Co., 50, Mark Lane, E.C.
Selby, H., and E., 33, Mark Lane, E.C.
Stevenson, George, 104, Lower Thames Street.
Sandford, W., Pilot and Tug Owner, Gravesend.
Skinner, Thos. and Co., Ship Owners, 5, East India Avenue, E.C.
Soundy, and Hornbuckle, Lightermen, Water Lane, E.C.
Shoring, Ephraim, Lighterman, East India Dock, E.
Shand, G. L., Pickle Herring, Southwark, Director London Steam Boat Co.
Smith, Capt. J. Henderson, H.M.S., "Worcester," Greenhithe.
Stewart, Charles H., C.C., Shipowner (and Member of the Marine Board), 6, Billiter Street, E.C.
Taylor, Chas., Coal Factor, 9, Fenchurch Avenue.
Taylor, Seth, Waterloo Flour Mills, Commercial Road, Lambeth, S.E.
Trinder, Anderson & Co., "Elder Line," 110, Fenchurch Street, E.C.
Thompson, W. T., Lighterman, Bishopsgate Street Within.
Thompson and Co., Geo., Shipowners, Leadenhall Street.
Taylor, Hugh, Ship and Coal Owner, Sunderland.
Umfreville, S. C., J.P., Greenhithe
Usborne, Thomas, South Sea House, Threadneedle Street.
Walker, Fredk., R.N., Captain and Superintendent Training Ship "Arethusa," Greenhithe.
Wood, G. E., Shipowner, Coal Exchange.
Wood, John, Shipowner, &c., Coal Exchange.
Wood, N., Shipowner, &c., Coal Exchange.
Woolner and Morton, 3, Muscovy Court, Tower Hill, E.C.
Woodley, M. F. and Co., 79, Mark Lane, E.C.
Williams, Samuel, Ship and Steam Tug Owner, Upper Thames Street.
Watts, Ward and Co., 85, Gracechurch Street, E.C.
Wescott, John B., Shipowner, &c., 11, London Street, E.C.
Williams, Brown and Elmslie, Wharfingers, Southwark.
Watkins, Wm., Steam Ship and Tug Owner, Mark Lane.
Worland, Hy., Wharfinger, Member West Ham Local Board, Victoria Dock Road, E.
Wright, Alfred, Medical Officer of Health, Romford.
Wilson, John, Shipowner, Clement's Lane.

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Summary of the above Members of the General Committee.

| | |
|---|---|
| Members of Parliament | 16 |
| Admiral | 1 |
| Shipowners and Dock Companies | 33 |
| Master of the Watermen's Company, representing many thousands of Lightermen and Watermen on the Thames | 1 |
| Individual Lightermen | 13 |
| Medical Officers of Health, including Medical Officer of Port of London | 13 |
| Steamship Companies—Peninsular and Oriental, British India, Orient, Glen Line, Japan Line, Anchor Line, London Steamboat Company, &c., &c. | 8 |
| Captains of Warspite, Cornwall, and Arethusa Training Ships | 3 |
| Captains R.N., including an Elder Brother of Trinity House | 5 |
| Wharfingers | 20 |
| Coal, Corn, and Flour Factors | 19 |
| Gentlemen, and Two Members of Thames Conservancy | 6 |
| Ship, Provision, and Wood Brokers | 8 |
| Merchants and Members of Lloyds | 7 |
| District Officers | 4 |
| Fish Salesmen (Wholesale) | 2 |
| | 159 |

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App. L.

## APPENDIX L.

### Letter from Capt. Burstal to Sir Benjamin Hall.

(Metropolitan Sewage Discharge Commission.)

32, Abingdon Street, Westminster,
Sir, November 18th, 1856.

On remarking upon the points of outfall for the sewage of the metropolis, I beg to inform you that the conclusions to which I have arrived relative to the drift of the stream are from the observations I made on the river in June last, from which I estimate the drift during the last 1½ hour of the flood tide to be 3¾ miles at springs, and 3 miles at neaps; consequently the water which passes point B. at ½ a mile below the Half Way House will (during springs) reach the town of Woolwich before it is arrested by the ebb stream, and at neaps ¼ mile below the Royal Arsenal.

I should, therefore, submit that the nearest point to London at which the outfall be made (so as to be at all times certain that the first portion discharged at 1½ hour before high water would not flow in or near the inhabited part of the metropolis) be in the upper part of Erith Reach, 15 miles from London Bridge, ½ mile from Erith Church, and ¾ mile below Jenningtree Point, nearly opposite Rainham Creek. From this, as a point of outfall, commencing at 1½ hour before the time of high water there, the upper portion of the sewage would at springs be opposite Barking Creek, and at neaps off the Magazine in the lower part of Barking Reach, near the metropolitan boundary. It cannot, therefore, be said that even from this position the sewage would be perfectly clear of the eastern limit

of the metropolis at spring tides, but it is certainly far enongh from any inhabited district to guarantee that (with those long floods caused by north and north-west winds) the river would not be polluted in the vicinity of Woolwich.

The additional length of drain necessary to be constructed to this outfall is exactly 1 mile, the space of river above the outfall thus freed from sewage would be $1\frac{7}{8}$ mile.

For similar reasons to those above stated, I would beg to suggest that the outfall on the north side be at Rainham Creek, which would be an extension of mile beyond that proposed.

With reference to the time that the pumping of sewage into the river should cease, I would state that the water which passes the outfall at 3 hours after high water will be carried 8 miles down, and back by the return flood about 13 miles, or 5 miles above the outfall, therefore the latest period at which that process should be admitted is something short of 3 hours after the time of high water; it therefore becomes necessary, if a period of 4 hours is requisite for the discharge of the sewage from the reservoir, supposing that reservoir is of sufficient capacity to contain it all, it stands to reason that the period of discharge should commence at least $1\frac{1}{2}$ hour before the time of high water.

If, however, it should appear that the capacity of the reservoir is not such as will contain the whole of the sewage that may arrive from the metropolis between the one period of discharge and the next, the dimension of the reservoir must be enlarged to meet the requirement.

I beg also to call your attention to the fact that when it was proposed to have the outfall at A. (within the metropolis) the reservoir was to contain 4,000,000 cubic feet; it is now proposed to have the outfall at B. in Half-way Reach, and the reservoir when full is to contain only 1,764,000 cubic feet and to cover a space of $4\frac{1}{2}$ acres.

On this, the south side of the river, for which the above provision is made, the amount of sewage is calculated by Mr. Bazalgette at $1\frac{1}{4}$ million cubic feet.

On the north side of the river Mr. Bazalgette states the amount of sewage to be six million cubic feet, whilst the reservoir proposed there is to be only double the size of that on the south side; in this there is a discrepancy of proportion, because the area of the reservoir on the north side of the river is to be 9 acres, and consequently 2 to 1; the amount of sewage is 6 million cubic feet, therefore 5 to 1.

In cases of heavy rains it would be necessary to provide for the great accumulation of water which would run into the drain, either by outlets or a larger reservoir: in the first instance the surplus quantity would flow into the Thames at various places, carrying with it a portion of sewage in solution; and in the last, immediately on the appearance of an extra supply in the reservoir, it would be imperative to commence pumping irrespective of the time of tide.

I have, &c.
(Signed) Edward Burstal,
Commander R.N.

The Right Hon.
Sir Benjn. Hall, Bart, M.P.
&c. &c. &c.

## APPENDIX N.



Correspondence, &c. received from the Thames Conservancy Board, July 1882.

Thames Conservancy,
Harbour Master's Office,
17th July 1879.

Sir,

I have the honor to report that in rowing up the north shore of the river at three-quarters ebb on the 26th June last at 11.30 a.m., on approaching the Storm Outlet at Ratcliff Cross I encountered a great quantity of sewage matter of the worst possible kind issuing from that outlet. It could not have been worse if we had been in the sewer itself.

The time was just below low water, and, as a natural consequence, all this excrement would be carried up the river with the flood tide, polluting and being deposited in the higher reaches.

I beg to state I called the attention of the Sanitary Inspector's launch to the matter, and they proceeded to take a sample.

I have, &c.,
(Signed) Richard Marsden.

To Captain Burstal,
Secretary,
Thames Conservancy.

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Thames Conservancy,
41, Trinity Square,
Tower Hill, E.C.,
23rd July 1879.

Dear Sir,

I am directed by the Conservators of the River Thames to transmit herewith, for the information of the Metropolitan Board of Works, a copy of a report they have received from Capt. Marsden, their deputy harbour master, to the effect that sewage was discharged into the river from the Storm outlet at Ratcliff Cross at three-quarters ebb, on the 26th ultimo, at such a time that it would be carried up the river on the flood tide.

I am, &c.,
(Signed) E. Burstal.
Secretary.

The Clerk of the
Metropolitan Board of Works.

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Thames Conservancy,
Harbour Master's Office,
Woolwich Dockyard,
16th July 1880.

Dear Sir,

The river water every day and night during the last month has been heavily charged with sewage; the odour even as far as Blackwall is worse than I have ever known it. The water last Monday at nearly half flood was so bad that I landed at the southern outfall to ascertain if the sluices were not open.

The foreman assured me they were closed. I can only say that immediately below the works the water was comparatively clear, and the air was almost free from the smell of sewage, but the nuisance still continues to be felt, and is spoken of on all sides.

Believe, &c.,
(Signed) J. Fitzgerald,
Harbour Master,
Central District.

Captain Burstal, R.N.,
41, Trinity Square.

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Thames Conservancy,
Harbour Master's Office,
Woolwich Dockyard,
25th July 1880.

Gentlemen,

Since my last report on the state of the river the water has become much worse, and it is now so heavily charged with sewage matter that it cannot be used for the decks, or even in the cisterns, and has become a public nuisance.

I have frequently traversed the river of late from side to side for the purpose of ascertaining its real state, and I have to report that throughout the whole length of my district (from Greenwich to Greenhithe) the water has been foul, and from Erith upwards the water is crowded with sewage at all times of tide.

The stream between Halfway Reach and Woolwich is nearly black at half tide both on the flood and ebb, and I have no hesitation in describing it as little better than an open sewer in this part of the river.

At the top of high water sewage is present in all directions, which is quite a new feature in my experience.

Yesterday off Greenwich at high tide the river was full of sewage, and the stench abominable; how far it extends upward I cannot say.

Occasionally streaks of apparently clear water are visible at the top of the tide, but it is only surface deep, since in the wake of every steamer a line of sewage can be traced which has been stirred up from underneath. The river has not been in its present condition, within the experience of anyone I have met, since the opening of the Metropolitan Works at Barking and Crossness, and I attribute it to three causes, chief of which is the discharge of sewage on the flood tide; it is no secret that this frequently takes place during the prevalence of rain, at which times the culverts and reservoirs become too heavily charged.

Secondly, the young flood tide disturbs the surface matter which has been deposited on the banks and

App. N.

foreshores during the preceding ebb, and sweeps it up the river.

And lastly, the sluicing operations at Victoria Docks (new entrance) contributes its share. These operations must of necessity be carried out at low water and repeated periodically. The matter thus disturbed from the bed of the river is also swept up by the following flood tide.

It is my opinion that the present filthy state of the river calls for the immediate attention of the Port Sanitary Authorities.

I have, &c.,
(Signed) J. Fitzgerald.
Harbour Master,
Central District.

To the Conservators of the River Thames.

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Thames Conservancy,
Harbour Master's Office,
41, Trinity Square,
26th July 1880.

Sir,

I have the honor to report for the information of the Board that the river on the flood tide on Saturday 24th instant was in a very bad state, the water black and full of filthy black-looking matter in suspense, and giving forth a most disagreeable smell. At Millwall it got worse; and off Port of London Wharf and as far as East Greenwich at three-quarter flood and up to high water the odour was horrible and sickening. I was engaged there for some little time about a launch, and the effect was felt by all the crew of my boat.

I have, &c,
(Signed) Richard Marsden,
Deputy Harbour Master.

Captain Burstal, R.N.,
Secretary,
Thames Conservancy.

To the Conservators of the River Thames.

---

*Private and Confidential.*

Port of London Sanitary Office,
Deptford, S.E.,
27th July 1880.

Dear Sir,

I wish to call the attention of the Conservators of the River Thames to the extremely unsatisfactory state of the water at the present time.

As you are aware this authority has no actual power nor jurisdiction in the matter, but we cannot fail to realize the fact that, unless the condition of the river materially improves, any continued hot weather will almost certainly cause a serious outbreak of disease, the work consequent on which must obviously fall upon our heads, and for which (though utterly powerless to prevent it) we shall to a great extent be held to blame.

For many days the water has been of dark colour and foul smell, though it varies very much from time to time.

I have examined samples in many places when thus bad, and have found them to be simply "diluted sewage." How far this is due to the Metropolitan Board of Works outfalls is a question which of course cannot be at once decided upon.

I take this opportunity of simply informing you privately of the *facts*, and shall be glad to hear of anything which will tend to check this very serious evil.

It occurred to me that if the Conservators were about to take action in any form any information or assistance would be of service.

I am, &c.,
(Signed) W. Collingridge,
Port Medical Officer.

To the Conservators, of the Thames.
Capt. Burstal, R.N.

The worst parts of the river *at present* are Woolwich, Erith, and Cherry Tree Point.

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Thames Conservancy,
41, Trinity Square,
Tower Hill, E.C.,
8th September 1880.

Dear Sir,

I have laid your letter of the 27th July last before the Conservators of the River Thames, who desire me to thank you for the communication, and to suggest you should lay your statement before the Metropolitan Board of Works.

Yours, &c.,
(Signed) E. Burstal,
Secretary.

W. Collingridge, Esq.,
Port Medical Officer,
Deptford.

---

"Warspite," Woolwich,
27th July 1880.

Dear Sir,

I think it my duty to report, for the information of the Committee, the bad state of the river where this ship is lying. It is no exaggeration to say that for several days past the whole river has been neither more nor less than an open sewer, the water of a dark slate colour, and large masses of solid sewage floating past. I communicated with Dr. Collingridge, the medical officer of the port of London, and also with the harbour master, sending them samples of the water from alongside. I have had visits from both those officials, who entirely concur in what I report. Dr. Collingridge said that he had analysed the water which I sent him, and found it to be "slightly diluted sewage." There is no doubt in my mind that the sluices at the outfall have been opened some hours before high water, as I have observed the whole river black with sewage at or about half-flood tide. I would suggest that a letter be sent to the Metropolitan Board of Works that they may take steps to forbid the sluices being opened while the tide is flowing, in order, if possible, to abate this horrible nuisance, which, if continued, must, I fear, cause a serious outbreak of sickness.

I am, &c.,
(Signed) A. W. Gillett,
Captain, R.N.

The Secretary,
Marine Society.

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1, Peveril Street,
Battersea,
7th December 1880.

Sir,

I beg to inform you that the sewers next below London Bridge, at Dowgate, at Saint Paul's, at Blackfriars, and the pumping station Grosvenor Road, were discharging very offensive matter into the river on the 6th and 7th instant.

I have observed this on several occasions during the past week, the discharge prevailing from half ebb and on the young flood.

I am, &c.,
(Signed) H. Little,
Inspector.

Captain Burstal, R.N.,
Secretary.

---

Thames Conservancy,
41, Trinity Square,
Tower Hill, E.C.,
16th December 1880.

Sir,

I am directed by the Conservators of the River Thames to forward herewith a copy of a report which has been received by them from their River Inspector, Mr. H. Little, in which he calls attention to the discharge of offensive matter into the river from the sewers next below London Bridge, at Dowgate, at Saint Paul's Pier, at Blackfriars, and at the pumping station Grosvenor Road, Pimlico.

I am further to call your attention to the fact that this discharge occurred after a long continuance of dry weather, and to request that you will bring the subject under the consideration of the Metropolitan Board of Works with a view to ascertaining whether they are prepared to take any steps to prevent the discharge of sewage into the river from the sewer outlets above-named.

I am, &c.,
(Signed) E. Burstal,
Secretary.

The Clerk of the Metropolitan Board of Works.

---

Thames Conservancy.
Harbour Master's Office,
5th July 1881.

Sir,

I beg to inform you that the water of the river is this day very offensive on the ebb, more particularly so at high water this morning.

I am, &c.,
(Signed) C. H. James,
Harbour Master.

To Captain Burstal.

---

Thames Conservancy,
41, Trinity Square,
Tower Hill, E.C.,
14th July 1881.

SIR,

I HAVE to inform you that the water of the river was very dark, discoloured, and offensive this day towards high water.

I am, &c.,
(Signed) C. H. JAMES,
Harbour Master.

Captain Burstal.

---

Thames Conservancy,
Harbour Master's Office,
Woolwich Dockyard,
20th July 1881.

DEAR SIR,

I FEEL it my duty to bring to the notice of the Conservators the present state of the river within my district. During the past week it has been in a very filthy state, and I fear there is every prospect of its continuance. The river between Purfleet and Charlton more especially is heavily charged with sewage matter, which is visible at all times of tide, and its sickly odour pervades every part of the district.

Yours, &c.,
(Signed) J. FITZGERALD,
Harbour Master,
Central District.

Captain Burstal, R.N.,
41, Trinity Square,
London.

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Trinity House, London,
21st July 1881.

DEAR SIR,

I BEG to draw your attention to the filthy state of the river between Blackwall and Tripcock Point. I slept on board the "Galatea" on Sunday night last, and was obliged to close the scuttle, owing to the smell of the water passing the paddles. There was no mistaking it for that of the chemical works, and the water was quite black. Everybody I met was complaining bitterly about the state of the river.

I am, &c.,
(Signed) WM. WOOLCOTT.

To Admiral
Sir F. Nicholson, Bart.

I beg you will make use of my name in this matter if you think fit.

(Signed) W. W.

---

Port of London Sanitary Offices,
King William Street, Greenwich, S.E.,
21st July 1881.

SIR,

I WISH once more to call the attention of the Thames Conservancy (as the guardians of the river) to the extremely foul and filthy state of the water at the present time.

During the hot days we had last week and the beginning of this week the odour has been very bad indeed, especially at high tide, and during the first part of the ebb.

This authority has done much to improve this by closing and diverting foul outfalls, but is now advised that it has no jurisdiction in the matter, such power resting with the Thames Conservancy. Under these circumstances I felt it a duty to call your attention to a condition of affairs which, if hot weather continue, may at any time lead to a serious outbreak of disease.

Yours, &c.,
(Signed) W. COLLINGRIDGE,
Port Medical Officer.

To the Secretary,
Thames Conservancy,
Captain Burstal, R.N.

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Thames Conservancy,
41, Trinity Square,
Tower Hill, E.C.,
27th July 1881.

SIR,

I HAVE laid your letter of the 21st instant before the Conservators of the River Thames, who have ordered a copy of it to be sent to the Metropolitan Board of Works, in whose jurisdiction the sewage is which causes the pollution referred to by you.

I am, &c.,
(Signed) E. BURSTAL,
Secretary.

W. Collingridge, Esq.,
Port Medical Officer,
Port of London Sanitary
Authority, Greenwich.

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Thames Conservancy,
41, Trinity Square, E.C.
27th July 1881.

SIR,

THE Conservators of the River Thames having received several representations of the contaminated condition of the river water during the year 1880 and the present year, especially during the hot and dry weather in the month of July, have directed me to send copies of the letters containing these representations for the information of the Metropolitan Board of Works.*

I am, &c.,
(Signed) E. BURSTAL,
Secretary.

The Clerk of the
Metropolitan Board of Works.

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The London Steamboat Company,
Adelaide Buildings (Limited),
London Bridge, 25th July 1881.

DEAR SIR,

WE have lately had so many complaints from our captains, as well as from passengers by our steamboats, that we now send you from our lessees a formal complaint setting forth the facts referred to in language unmistakeable. It is difficult to fix responsibility, but, as conservators of the river and protectors of the navigation, we appeal to you, and trust you will exercise your powerful influence in securing a remedy for these evils.

Yours, &c.,
(Signed) GEO. WM. LAKEMAN,
Secretary.

Captain Burstal, R.N.,
Secretary, Thames Conservancy.

(For copy of a letter herein referred to, see next sheet.)

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Thames and Channel Steamship
Company (Limited),
Adelaide Buildings,
London Bridge,
25th July 1881.

DEAR SIR,

I BEG to request you will communicate with the Thames Conservancy Board as to the filthy state of the river below bridge, more particularly about Woolwich. The effluvia thrown off by the sewage floating up and down in the stream is positively poisonous, the river being for miles black with it. As an instance, yesterday morning at 10 o'clock the passengers on board the "Eclair" at Woolwich were seriously annoyed; the smell was almost unbearable.

I am sure it is very detrimental to our interests, and appears to be caused by the discharge being made into the river on the flood instead of the ebb tide. I trust you will use your best endeavours to have this nuisance remedied.

Yours, &c.,
(Signed) J. R. PEARSON,
General Manager and Secretary.

The Chairman,
London Steamboat Company.

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Thames Conservancy,
41, Trinity Square, Tower Hill,
Monday, 22nd August 1881.

Captain Fitzgerald took to Mr. Wigner, at 79, Great Tower Street, a sample bottle of river water taken in Barking Reach, 30 yards off the northern outfall, 2¾ hours *before* high water, 19th August 1881. Bottle sealed with red sealing-wax and seal of Captain Fitzgerald.

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Laboratory,
79, Great Tower Street,
London, E.C.,
29th August 1881.

CERTIFICATE OF ANALYSIS.

Sample of water taken from Barking Reach on 19th August 1881. Sealed, a griffin with letters and cypher beneath, and marked river water taken in Barking

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* ENCLOSURES.

Harbour Master's Reports :—
16th July 1880.
25th " "
26th " "
5th July 1881.
14th "
20th "
Port of London Sanitary Authority, 21st July 1881.
London Steamboat Company, 25th July 1881.
Thames and Channel Steamship Company, 25th July 1881.
Trinity House, Captain Woolcott, 21st July 1881

App. N.

Reach, 30 yards off the northern outfall, 2¾ hours before high water. Received from the Hon. the Conservators of the River Thames on the 22nd August 1881.

I certify that I have examined the above sample, and that the following are the results:—

*Physical Characteristics.*

Action on test paper, faint alkaline.

Amount of alkalinity calculated as carbonate of soda, 37·10.

Smell, offensive of sewage.

Sulphuretted hydrogen, heavy.

Suspended matter, heavy.

Appearance of suspended matter, black, flocculent, and earthy.

Appearance of sample before filtration, black, thick from suspended matter.

Appearance of sample after filtration, brownish-yellow, slightly opaque.

Hardness before boiling, 21°·5, Clark's scale.

*Chemical Results.*

| | Grains per Gallon. |
|---|---|
| Suspended matter: | |
| Volatile organic matter | 80·90 |
| Mineral matter | 185·10 |
| Total | 266·00 |
| Dissolved matter: | |
| Volatile organic matter | 22·80 |
| Mineral matter | 168·80 |
| Total | 191·60 |
| General composition of mineral matter: | |
| Lime combined as salts | 10·08 |
| Chloride of sodium (common salt) | 143·32 |
| The dissolved organic matter contained— | |
| Nitrogen as ammonia | 1·9990 |
| ,, albuminoid ammonia | ·1260 |
| And absorbed oxygen from permanganate equal to | 1·3330 |

*Microscopical Results.*

Animal and vegetable débris in excessive quantity. Hairs, animalculæ, and vegetable spores of various species, such as vibriones spirillum, acomia paramecia, desmids confervaceæ. General appearance of sewage matter.

*Opinion.*

This sample is simply diluted sewage. There is some salt water mixed with it, and doubtless a small proportion of fresh river water also; but as far as concerns its offensive character and liability to cause deposit of decomposing matter, it is as bad as average London sewage.

(Signed) G. W. Wigner, F.C.S., F.I.C.

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Thames Conservancy,
41, Trinity Square,
Tower Hill, E.C.,
14th September 1881.

Sir,

I am directed by the Conservators of the River Thames to transmit herewith a copy of a report of an analysis made by Mr. Wigner, F.C.S., of a sample of fluid taken from the river in Barking Reach, 30 yards off the northern sewage outfall, on the 19th ultimo, 2¾ hours before high water, and I am to request that you will bring the same under the consideration of the Metropolitan Board of Works.

I am, &c.,
(Signed) E. Bursтal,
Secretary.

J. E. Wakefield, Esq.,
Metropolitan Board of Works.

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Local Government Board,
Whitehall, S.W.,
3rd November 1881.

Sir,

I am directed by the Local Government Board to transmit to you, for the consideration of the Conservators of the River Thames, the accompanying copy of a letter which the Board have received from the vestry of Plumstead, containing a copy of a resolution passed by them with regard to the pollution of the River Thames by sewage from the works executed under the Metropolis Local Management Acts.

At the same time I am to state that the attention of the Board has also been drawn to the alleged nuisance occasioned by the works in question by an influential and representative deputation from the locality.

The Board are desirous, therefore, of being furnished with the observations of the Conservators on the subject.

I am, &c.,
(Signed) Walter J. Sendall,
Assistant Secretary.

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Plumstead,
20th September 1881.

Sir,

I am requested to forward a resolution passed by the vestry of Plumstead at their meeting on the 18th instant:—

"That this vestry expresses its abhorrence at the continued impurities from sewage existing in the Thames near the metropolis, contrary to the 135th section of the Metropolis Local Management Act, 1855, and that this resolution be forwarded to the Local Government Board, with an earnest hope that it will concert measures to remedy the evil complained of."

I have, &c.,
(Signed) Edwin Hughes,
Vestry Clerk.

To the Secretary to the
Local Government Board.

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Thames Conservancy,
41, Trinity Square,
Tower Hill, E.C.,
16th November 1881.

Sir,

I am directed by the Conservators of the River Thames to acknowledge the receipt of your letter of the 3rd instant (No. 89,921 K. (1)), with its enclosure, being a copy of a resolution passed by the vestry of Plumstead on the 18th September last, on the subject of the polluted condition of the river, said to be caused by the impurities passed into it from the sewage outfalls.

In compliance with the request contained in your letter that the Conservators would furnish the Local Government Board with their observations on this subject, I am to state that the Conservators are fully aware of the contaminated state of the river and the offensive odour arising therefrom during the summer months; that letters have been addressed by them to the Metropolitan Board of Works, enclosing copies of reports on the subject. The Conservators beg to refer you to the concluding paragraphs of their report to Parliament, dated 25th July, wherein this subject is prominently referred to; also to the minutes of evidence given before the umpire and arbitrators in 1879, when the question relating to mud deposits in the river was brought before them, in which the witnesses referred in strong terms to the offensive state of the river, caused by the sewage that was passed into it from the outfalls at Barking and Crossness; but as that inquiry was based upon sections 20 and 21 of the Thames Navigation Act of 1870, the question of pollution of the river did not come within the scope of it.

In order that you may readily see what has been received by the Conservators on the subject referred to in this letter, an extract from the report to Parliament and copies of letters and reports are herewith enclosed, as named in the accompanying list.

I am, &c.,
(Signed) E. Bursтal,
Secretary.

The Assistant Secretary,
Local Government Board,
Whitehall, S.W.

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Extract from the Conservators of the River Thames Annual Report to Parliament, dated 25th July 1881.

During hot weather, when there has been little rainfall, complaints of the pollution of the river within and below the metropolitan district frequently reach the Conservators.

The pollution thus complained of is indicated by the offensive odour and highly discoloured state of the water. It must be remembered that Kingston and Richmond, and other places below the intakes of the water companies, still pass their sewage into the river, the penalties for their doing so having been suspended

by the Legislature to give time for overcoming the difficulties of carrying out a complete sewage system for this district.

Although the discharges from these places may in some degree affect the purity of the river near the metropolis, it can hardly be doubted that the chief cause of the polluted state of the river within and below the metropolis arises from the discharge at the outfalls and storm outlets of the Metropolitan Board of Works, in whose district ordinary sewage is exempted from the provisions of the purification section in the Conservancy Acts.

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Extracts from Evidence before the Arbitrators in 1879, as to Offensive Smells from the Polluted Water from the Sewers.

Captain James, harbour-master, Nos. 1256–69.
Captain Fitzgerald, harbour-master, central district Nos. 1386–93, 1397–1411, 1560–66.
Mr. John Grevill Fennell, Nos. 1881–1902.
Mr. James C. Walker, pilot, Nos. 2654–62, 2734–36, 2739–43.
Mr. J. H. Cavill, pilot, Nos. 2781–84.

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Extracts from the Harbour-Master's Journal (Central Station) for the Years 1878–81.

1878.

20 Dec.—Tides very sluggish, owing to which the water in Halfway Reach, and also in Barking Reach, was found to be in a very foul state and heavily charged with sewage.

1879.

2 Jan.—Tide sluggish. Water in Halfway Reach heavily charged with sewage matter.

16 July.—Watchman on board steamer "Conservator" at Charlton reports a strong smell of sewage round the vessel on the flood tide.

19 July.—A strong smell of sewage round the vessel at her moorings, and the water presenting all the appearances of being charged with sewage matter.

1880.

24 June.—A smell from the river water most offensive, which continued the entire day. The stream, both on flood and ebb, apparently charged with sewage.

25 June.—A smell of sewage pervaded the river from Charlton to Erith, quite as bad as on previous day.

26 June.—Smell from river water still offensive, but not so bad as yesterday.

6 July.—A very offensive smell from the river water in the lower part of the district, especially in Erith Reach, although the water was comparatively clear.

7 July.—River smelling very badly in Erith and Halfway Reaches, and a good deal discoloured with sewage below Barking Creek.

9 July.—River water much discoloured and smelling badly.

11 July.—River water strongly impregnated with sewage and smelling badly.

12 July.—Landed at southern outfall this day at half flood to complain of the state of the river. Was informed that the sluices had been opened at the usual time;—a statement which I was inclined to doubt, owing to the river water below the works being comparatively clear and the air free from sewage taint; whereas in Barking Reach and immediately above the works it was just the reverse.

13 July.—River water in a very bad state off Charlton and Woolwich.

15 July.—River water greatly discoloured with sewage in Bugsby's and Blackwall Reaches, and smelling very badly.

17 July.—The river to-day on the ebb and up to the following half flood, between Woolwich and Erith, was in a worse condition than I have ever known it. The water throughout the above-mentioned part of the river was heavily charged with sewage from side to side, and the stench almost unbearable.

18 July.—River in Woolwich Reach almost black with sewage matter.

19 July.—River water much clearer on the surface to-day, but very thick inshore.

21 July.—River water this day fairly clear on surface, but filthy and stinking underneath, every steamer leaving discoloured water in her wake. Just above Leather Bottle Point the water was nearly black at the last quarter flood, covering a space of nearly a mile.

22 July.—River in filthy condition between Charlton and Erith. Sewage apparently working its way higher up the river.

23 July.—River between Charlton and Erith in filthy condition at low water, and the stench abominable. Stream during whole flood heavily charged with sewage matter from side to side, nearly black in some places, and the river, even at high water, above Greenwich, full of sewage, and the odour disgusting.

24 July.—River water on surface at high water a little improved from previous day.

25 July.—River to-day again in a beastly state. William Turnnidge, of "Conservator," attributes his illness to the state of the river.

26 July.—At low water this day the river from Bugsby's down to Barking Creek was choked full of sewage, landing places and foreshores covered with it; stench abominable. The same on flood. Slightly better at high water, but on the ebb a strong smell of sewage present right across the river off Woolwich, the water becoming thicker as the tide fell.

27 July.—River water tolerably clear at high water this day; black streaks and patches visible at first quarter ebb.

28 July.—River water improved in appearance off Charlton, but full of sewage in Barking and Halfway Reaches at half ebb. Patches of sewage all over Long Reach, and smelling strong.

29 July.—Water in river rather better than on the previous day, owing to the prevalence of strong westerly winds. Surface water fairly clear and free from smell.

30 July.—Water in the river continues to improve, but the foreshores and some of the landing places and wharves are clothed with sewage mud.

31 July.—River continues to improve.

4 Aug.—River to-day much improved and free from smell, excepting in Halfway Reach.

5 Aug.—River water fairly clear and free from smell.

13 Aug.—River water this day smelling badly. Patches of sewage visible throughout this whole district, from Greenwich to Queenhithe, especially on first quarter flood.

20 Aug.—Water in river remains fairly clear and free from bad odour.

21 Aug.—River water moderately clear, but smelling badly at low water.

27 Aug.—River water throughout the district, both on ebb and flood, smelling strongly and of sewage; black patches to be seen in various parts.

14 Oct.—River water heavily charged with sewage matter this day, especially in Erith and Halfway Reaches. Air bubbles visible right across the river at low water.

1881.

14 July.—River water heavily charged with sewage and smelling badly.

18 July.—River this day very offensive and heavily charged with sewage.

19 July.—River this day in filthy condition, especially between Blackwall and Purfleet.

20 July.—River in a very bad state.

23 July.—River in an exceedingly bad state, even at high water.

25 July.—River water in filthy condition at half ebb, and stench most offensive.

26 July.—River at half ebb in a filthy state, being heavily charged with sewage.

27 July.—River still heavily charged with sewage.

App. N.

28 July.—River water very filthy this day, especially off Erith and Woolwich.
30 July.—River water this day rather better, and the smell not quite so offensive.
2 Aug.—River again very filthy at half tide, and the odour very offensive.
5 Aug.—River remains very filthy and full of sewage.
6 Aug.—River remains very filthy and full of sewage.
8 Aug.—River water this day somewhat improved in appearance, and not smelling so badly.
9 Aug.—Same as on previous day.
10 Aug.—River water in a filthy state on the ebb tide, especially in Halfway Reach and off Erith.
12 Aug.—River heavily charged with sewage, and smelling badly at half flood.
21 Aug.—Two hands at northern outfall, Barking Reach, at half flood (night tide), reports sewage coming through the sluices at 9.30 p.m. High water at 11.35 p.m. Geo. Lamerton and Thos. Long in the boat.

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Thames Conservancy,
Deputy Harbour Masters Office,
Limehouse,
6th July 1882.

Sir,

I beg to report to you that as I rowed past the following storm outlets this morning at 10.30, last quarter ebb, viz., Ratcliff Cross, Bell Wharf, and Coal Stairs, I passed through an immense quantity of bonâ fide sewage, and that the smell from it was most offensive.

I am, &c.,
(Signed) L. Bowen.

To Captain Burstal, R.N.
Secretary,
Thames Conservancy.

Extract from the General Report of the Conservators of the River Thames, from 1st January 1880 to 31st December 1880.

The periodical surveys of the river having shown that shoals had been formed in Halfway Reach since the opening of the Metropolitan sewage outfalls, the Conservators deemed it advisable that an inquiry should be held under sections 20 and 21 of the Conservancy Act 1870. That inquiry was limited to the question, whether a sufficient obstruction to the navigation had been caused to render the Metropolitan Board of Works liable for the removal of such obstruction.

This question the umpire and arbitrators decided in the negative.

It should be noticed, however, that the question of the pollution of the river could not be raised in this inquiry under the sections of the Act of 1870.

During hot weather, when there has been little rainfall, complaints of the pollution of the river within and below the Metropolitan District frequently reach the Conservators. The pollution thus complained of is indicated by the offensive odour and highly discoloured state of the water. It must be remembered that Kingston and Richmond, and other places below the intakes of the water companies, still pass their sewage into the river, the penalties for their doing so having been suspended by the legislature, to give time for overcoming the difficulties of carrying out a complete sewage system for this district.

Although the discharges from these places may in some degree affect the purity of the river near the Metropolis, it can hardly be doubted that the chief cause of the polluted state of the river within and below the Metropolis arises from the discharge at the outfalls and storm outlets of the Metropolitan Board of Works, in whose district ordinary sewage is exempted from the provisions of the purification sections in the Conservancy Acts.

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App. O.

## APPENDIX O.

Reports from the Officers of the Woolwich Local Board of Health, 1878.

Woolwich Local Board of Health.

Reports of the Surveyor and Analyst to the Woolwich Local Board of Health on the State of the Water of the River Thames. Presented to the Board on the 22nd October 1878, and ordered to be printed.

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The State of the River Thames.

At a Meeting of the Woolwich Local Board of Health, held at the Town Hall, Woolwich, on Tuesday the 8th day of October 1878,

Present,

John Taylor, Esq., Chairman, and 13 other members,

It was moved by Captain Behenna, R.A., seconded by S. C. Harrington, Esq., and resolved unanimously—

"That the surveyor be instructed to take samples of the water of the River Thames, at various points and depths, when the tide is about in the same state as when the accident occurred to the 'Princess Alice' steamboat, and that such samples be forwarded to Mr. Wigner, the Public Analyst, for analysis and report."

(Extracted from the Minutes of Proceedings.)
Andrew C. Reed,
Clerk to the Board.

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Report of H. O. Thomas, Assoc. Inst. C.E., Surveyor to the Woolwich Local Board of Health, on the State of the Water of the River Thames. Presented to the Board on the 22nd October 1878, and ordered to be printed.

*To the Woolwich Local Board of Health:—*

Gentlemen,

I beg to report that, in compliance with your instructions of the 9th instant to take samples of Thames water at a time of day and condition of tide corresponding as near as possible with the circumstances which prevailed when the accident to the "Princess Alice" occurred, and to obtain the water at various depths, I procured the loan of a steam launch from the Thames Conservancy Board, and on Monday, the 14th instant, accompanied by your analyst, Mr. Wigner, I left London Bridge a little before 3 o'clock, and obtained samples of Thames water at the places mentioned in the annexed schedule. The tide was high at London Bridge on this day at 3.15 p.m.

At every chosen place two samples were taken, one as near to the surface as could be (care being taken to avoid the scum on the surface), and the other sample at about half the depth of the river.

No. 10 was taken as near as possible to the spot where the wreck of the "Princess Alice" was found, and from nearly, but not quite, the bottom of the river.

All the samples, unless otherwise specified, were taken as nearly as possible at mid-stream.

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Schedule referred to in the foregoing Report.

| No. of Sample. | Time taken. | What part of River taken from. | Temperature of Sample. |
|---|---|---|---|
| | P.M. | | ° |
| 1 | 3 | Off Billingsgate, surface - - - | 56 |
| 2 | 3 | Do. 15 ft. deep - - | 56½ |
| 3 | 3.35 | Middle of Limehouse Reach, between Millwall and Commercial Docks, surface. | 58 |
| 4 | 3.35 | Do., 20 ft. deep - - | 58 |
| 5 | 4.40 | Opposite Charlton Pier, surface - - | 56½ |
| 6 | 4.40 | Do. 20 ft deep - | 56½ |
| 7 | 4.45 | Opposite North Woolwich Pier, surface | 56 |
| 8 | 4.45 | Do. 20 ft. deep | 56½ |

| No. of Sample. | Time taken. | What part of River taken from. | Temperature of Sample. |
|---|---|---|---|
| | P.M. | | ° |
| 9 | 5 | At Wreck opposite Powder Magazine, 20 ft. deep. | 56 |
| 10 | | At Wreck opposite Powder Magazine (bottom of River), 40 ft. deep. | 56 |
| 11 | | Do., surface - - - - | 55½ |
| 12 | .10 | Northern outfall, 5 ft. deep - - | 58 |
| | | NOTE.—The sewage was running from the sluice at this time, and the smell of the water in the vicinity was of a very offensive character. The sample was taken 50 ft. from the outlet. | |
| 13 | 5.20 | Half-way between Northern and Southern outfalls, surface. | 55 |
| 14 | 5.20 | Do., 20 ft. deep - - | 56 |
| 15 | 5.30 | Southern outfall, 10 ft. deep - - | 57 |
| | | NOTE.—The sewage was also running here, and the smell of the water was most offensive, even more so than that near the Northern outfall. This sample was taken about 20 ft. from the outlet. | |
| 16 | 5.40 | Jenningtree Point, below Southern outfall, 20 ft. deep. | 56½ |
| 17 | 5.40 | Do., surface - - - - | 56 |

FURTHER SAMPLES.

On the 19th instant, accompanied by an assistant of Mr. Wigner's, I procured another sample of water and one of mud, viz. :—

| No. of Sample. | Time taken. | What part of River taken from. |
|---|---|---|
| | P.M. | |
| 18 | 3 | Water from Beckton Gas Works outlet. |
| 19 | 3.10 | Mud between the Gas Works and the Northern outfall. |

These samples, after being carefully labelled, were all taken direct to the laboratory of Mr. Wigner, who will report to you the result of the analyses.

H. O. THOMAS, Assoc. Inst., C.E.,
Surveyor to the Woolwich
22nd October 1878. Local Board of Health.

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REPORT by G. W. WIGNER, F.C.S., upon the CONDITION of the RIVER THAMES from London Bridge to Woolwich, with special reference to the question as to whether the water was so contaminated by sewage discharge on the 3rd of September 1878 as to cause the death of any of the passengers on board the "Princess Alice," together with a TABULAR STATEMENT of results of the analyses of samples obtained at different points. Presented to the Board and ordered to be printed on the 22nd October 1878.

*To the Woolwich Local Board of Health:—*

GENTLEMEN,

IN accordance with the instructions given by the resolution of your Board on the 8th of October 1878, I have examined, both chemically and microscopically, a series of samples of water taken from the River Thames at various places, in order to ascertain whether the river is contaminated by drainage matter, and whether there is any foundation for the assertions that its foul condition had increased the number of deaths on the night of the unfortunate accident to the "Princess Alice."

Your surveyor, Mr. Thomas, and I, agreed that it was desirable I should accompany him when the samples were taken, in order to observe the condition of the river, and to take note of the temperature of the water where the samples were obtained, and any other physical conditions which might bear upon the matter of inquiry.

Accordingly, on the 14th October, in a steam launch kindly placed at our disposal by the Thames Conservancy Board, we obtained the necessary samples, and I now submit my report thereon as follows:—

As your Board are doubtless aware, reports on the state of the Thames have recently been presented to the Thames Conservancy by Captain Calver, and to the Metropolitan Board of Works by Sir J. Bazalgette and Messrs. Keates and Dupré, and it is necessary that I should refer to these reports, as they constitute part of the information which is available to enable a correct judgment to be formed of the condition of the river.

PRINCIPAL CAUSES OF VARIATION IN PURITY OF RIVER.

I must point out that in the tidal portion of the river in the vicinity of Woolwich the degree of contamination, if any, is seriously affected by at least three principal causes; and therefore, unless care is taken to procure samples under certain definite and well-known conditions, no useful information can be obtained. These three causes are—

1st. The rise and fall of the tide.

In this respect Mr. Thomas and I, in compliance with the resolution of the Board, took care that the samples from the neighbourhood of Woolwich were obtained under tidal conditions corresponding as nearly as was practicable with those which prevailed at the time of the accident to the "Princess Alice."

2nd. The flow of fresh water down the river, as shown by the amount of water flowing over Teddington Lock.

This flow is dependent upon the recent rainfall in the watershed drained by the upper reaches of the Thames. In reference to this point I find that on the day of the wreck the water at Teddington Lock stood at one foot over the mean summer level, and this had been about the average height for some days previously. On the 14th October, when my samples were taken, the water at the same place stood at eight inches over mean summer level, or only four inches less than it was on the date of the wreck; therefore, the conditions under which my samples were taken were in this respect also nearly identical with those which prevailed on the night of the wreck, and they represent rather more than the average amount of dilution of the river with the comparatively pure rainfall from the upper reaches. The conditions prevailing on the 15th January last, when the greater part of the samples reported upon by Messrs. Keates and Dupré to the Metropolitan Board were obtained, were, however, directly opposed to this.

3rd. The amount of sewage being discharged from the outfalls, which is necessarily dependent to a considerable extent on the recent rainfall in the Metropolitan district.

It is impossible for me to give an opinion whether the circumstances were in this respect the same when my samples were taken as on the night of the wreck.

STATE OF RIVER WHEN MESSRS. KEATES' AND DUPRÉ'S SAMPLES WERE TAKEN.

I must now point out to your Board that the analyses of the large number of samples taken on the 15th January, and examined by Messrs Keates and Dupré, and which are mainly relied upon by the Metropolitan Board as proofs of the pure state of the river, do not throw any light whatever on its ordinary condition at and near to Woolwich, because, as has been pointed out by Captain Calver, the river had for some month or so prior to that date been in flood, and the water level at Teddington standing from 3 feet to 5 feet 9 inches above the standard summer level. Captain Calver remarks: "The effect of this enormous discharge "was, of course, to substitute *pure for impure* water "throughout the whole length of the Thames from "Teddington to the sea."

A comparison of the results of the analyses which I now submit with those of Messrs. Keates and Dupré will show that this statement is fully borne out, as the body of comparatively pure water which was going down when their samples were taken was so enormous relatively to the ordinary or normal condition of the river, and to the size of the river basin, that the water in the centre of the river off Billingsgate on the 14th October contained as large an admixture of sea-water as Messrs. Keates and Dupré found at the same time of the tide at Erith, some 12 or 14 miles lower down the river; or, to put it in another way, the whole basin of the Thames from Teddington to Erith was on

APP. O.

the 15th January filled with water which consisted of a large proportion of pure river water which had come over Teddington Weir, and a smaller proportion of sea-water, or water which had come up the river, than was present on the 14th October at Billingsgate.

It is obvious, therefore, that the time selected by the Metropolitan Board of Works for the collection of their series of nearly 400 samples was that when the river at and near Woolwich was under the most favourable conditions possible, since the enormous scour produced by this large body of fresh and comparatively pure water had carried the impurities down to the sea.

On the other hand, Mr. Thomas and I selected a time when the conditions as regards the body of water coming down represented a fair average.

With these preliminary observations I pass to consider the following questions:—

1. Is the river contaminated with sewage?
2. If so, is the sewage contamination so great as to be injurious to Woolwich?
3. Is it probable that the condition of the river on the night of the accident was so bad that some of the drowning people were poisoned by it, or that the loss of life was increased by it in any other way?
4. If this contamination exists, is it due to the sewage from the Metropolitan outfalls?

### Is the River contaminated with Sewage?

1. In my opinion the river is contaminated with sewage, although the extent or degree of this contamination, and the amount of decomposition which has ensued, differs considerably at various points. From the tabular statement which accompanies this report it will be seen that samples were taken from the immediate neighbourhood of the northern and southern outfalls, and at seven other points, viz., off Billingsgate, Limehouse Reach, off Charlton Pier, off North Woolwich Pier, at the spot where the wreck of the "Princess Alice" was found, half way beneath the northern and southern out-falls, and at Jenning-tree Point. At each place samples were taken at the surface and about half way between the surface and the bottom of the river.

All these samples show by the chlorine present a large admixture of sea water with the fresh water coming down the river and the sewers; and the proportion of this admixture increases, as might be expected, with tolerable regularity in proceeding down the river. At Billingsgate the proportion of sea water is about 10 per cent. of the total volume. In Limehouse Reach this has more than doubled; and at the wreck the proportion is probably about 35 per cent. of sea water to 65 per cent. of fresh water. This fact is important, as sewage, when diluted with sea water, gives off more offensive effluvia than when diluted with fresh river water.

A remarkable fact is, however, to be noticed in the figures in the accompanying table, viz., that in almost every case the water at the lower part of the river contains a larger proportion—in some cases a very much larger proportion—of salt than the water at the surface. This would seem to indicate that the sea water flows upwards along the bottom of the river, leaving the land water and sewage to pass nearer to the surface. Of course, very great admixture takes place between them, but still the general rule apparently holds good. This fact may have a very important bearing upon the question of the state of the river, inasmuch as, by the heaviest water running at the bottom with the flood tide, a large number of the lighter particles of sewage deposit (especially of those particles which are of organic origin, and therefore more injurious,) may be kept from subsiding as readily as would otherwise be the case; and they may, in fact, be held up so as to be carried up stream by the incoming flood tide rather than down stream by the ebb, and may thus increase the pollution of the Upper Reaches.

The amount of combined sulphuric acid present in the samples increases with tolerable regularity as we proceed down the river, with the exception of the samples from Jenning-tree Point. This combined sulphuric acid is partly decomposed by the organic matter of the sewage, and gives rise to the liberation of sulphuretted hydrogen, which has a most offensive smell.

All the samples I obtained were turbid and offensive in appearance, but there was no very marked difference between them, with the exception of the two taken at the outfalls. All of them had a more or less offensive smell. This smell in the Billingsgate samples was slight, although readily perceived on shaking up a small quantity of the water; but it gradually increased in the other samples, till, in those taken off Woolwich Pier, it became most objectionable, and one of these gave off a sensible quantity of sulphuretted hydrogen. The samples taken at the wreck were still worse, the surface sample having a most offensive smell, and the other two samples but little less. In the samples taken midway between the outfalls in mid-stream, the characteristic smell of sewage was quite apparent, while the Jenning-tree Point samples were somewhat better.

When the sedimentary matter was allowed to subside the samples had a yellowish brown colour, and in the case of one of those from between the northern and southern outfalls this approached to a full urine yellow.

The amount of organic matter dissolved by the water, all of which must have been derived from animal or vegetable contamination, varied greatly at different points. Off Billingsgate there were only 30 to 35 grs. per gall., but the surface sample from Limehouse Reach showed 516 grs. per gall., *i.e.*, considerably more than 1 oz. per gall. of matter capable of putrefying. This proportion does not change with anything like the regularity that the mineral constituents do. Thus we find that there were 361 grs. of organic matter per gall. in the surface sample off Charlton Pier, and 154 grs. per gall. in the deep sample; while at Woolwich Pier there were 151 grs. per gall. in the surface sample, and 211 grs. per gall. in the deep sample. The surface sample from the wreck contained 140 grs. per gall., the mid-depth sample 212 grs. per gall., and the deep one 125 grs. per gall. One sample from Limehouse Reach and one from off Charlton Pier are rather worse than the worst of those taken from the wreck, but all the other samples are better than these.

Messrs. Keates and Dupré made a large number of estimations of suspended organic matter in the samples taken on January 15th, but, as the river was in flood, they of course found but little. I do not find that they made any similar determinations of dissolved organic matter.

The nitrogenous constituents, which are taken by many chemists as the main indication of sewage contamination, are somewhat lower throughout than I should have expected from the figures already quoted; but as they are fully set out in the table, I need not refer to them further than to say that they indicate very considerable contamination.

The amount of oxygen absorbed, which is a rough indication of the amount of oxidation necessary to convert these foul and offensive compounds into comparatively innocuous ones, is in nearly every case very high, most of the samples considerably exceeding half the figure found in the sample taken at the northern outfall.

The amount of suspended matter, that is, impurities which are capable of settling out of the water, is very variable. The sample taken from the wreck, at a depth of 40 feet., contained 4·9 grs. per gall. of suspended organic matter, and 27·4 grs. per gall. of suspended inorganic matter. One of the Billingsgate samples contained 16 grs. per gall., and one from Jenning-tree Point, which was the largest proportion found, 34 grs. per gall.

So far, the consideration of all the chemical results might be held to give amply sufficient proof of the presence of sewage; but, in addition, I have examined each sample microscopically, paying special attention to the characteristics of the sedimentary matter. I should point out here that animalculæ alone are not in themselves a proof of sewage contamination, but that the microscopical evidence of this has to be found mainly in the presence of fragments of cotton fibre, disintegrated paper, the skin or husk of wheat or other foods, and traces of partially digested or decomposed muscular fibre or other food.

The results of the microscopical examinations varied greatly. All the samples literally swarmed with living and dead animalculæ of various kinds. Most of those species found even as high up the river as Billingsgate corresponded with those found in the samples taken at the northern and southern outfalls. In the Billingsgate samples there was, in addition to a large number of infusoria and diatoms, unmistakable evidence of sewage contamination, inasmuch as I found in a single drop of the sediment from the water (which sediment was of a bluish black colour) one distinct piece of partially decomposed muscular fibre, a piece of the husk of wheat or one of the other cereals, several hairs, and a

considerable quantity of cotton fibre. We have here then an unmistakable proof that sewage had in some manner or other found its way to this place.

In the Limehouse Reach samples there was a very large quantity of disintegrated paper and cotton fibres, but no other structures peculiar to sewage could be recognised. In the Charlton Pier samples there were a considerable number of hairs, some evidently human and others being animal hairs. The sediment from the sample taken off North Woolwich Pier was of a much lighter and more flocculent character. It contained a very large amount of decaying vegetable tissue, but, with the exception of the dead animalculæ with which swarmed, no animal remains could be detected.

The samples taken from the scene of the wreck were unquestionably worse than the last referred to. In the sedimentary matter I found cotton fibre, fragments of muscular fibre, many fragments of paper, a fragment of husk of wheat, and some hairs.

I pass over the samples from the two outfalls, simply stating that, as was to be expected, they contained the most abundant evidence of decomposing sewage matter.

The samples taken midway between the two outfalls closely resembled those taken at the wreck, and the evidence of sewage contamination was unmistakable, while the samples from Jenning-tree Point showed a very large amount of disintegrated vegetable tissue and particles of cotton fibre.

I think the various facts detailed above in reference to the individual samples afford the most conclusive ground on which to base an opinion—that the whole of the river from Billingsgate to Jenning-tree Point was, on the 14th October last, greatly contaminated with sewage, and that, subject to certain irregularities which may be due to local circumstances in the river, this contamination increased as we passed down it, and that on the whole the greatest contamination was found in the samples taken at the wreck, and half-way between the two outfalls.

### Is the Sewage Contamination so great as to be injurious to Woolwich?

2. This question is unfortunately to a large extent a matter of opinion; but if the state of the river on the 14th October represents, as I have reason to believe it fairly does, its average state at Woolwich, my own opinion is that unquestionably the effluvia given off from the sewage contaminated water is sufficiently great to be injurious to health.

### Did the Condition of the River on September 3rd increase the Loss of Life?

3. In reply to this question, I do not think that, as far as can be judged from the samples I have examined, it would be right to say that any of the unfortunate passengers in the "Princess Alice" were absolutely poisoned by the water; but it does seem to me extremely probable that the intolerably nauseous smell, accompanied as it doubtless is by an equally nauseous taste, may have produced sudden vomiting in some of the persons in the water, and that by this means what little strength or power they had to save themselves by swimming may have been lost, or, as in the mere act of vomiting, the lungs may have been emptied of air and refilled with water; the body would thus become specifically heavier than water, and people may have sunk who might otherwise have been saved, had the water been in good and clean condition. While, therefore, I think it quite possible that some loss of life may be indirectly attributed to the foul condition of the river, I do not think it was sufficiently foul for the small quantity which could be imbibed to actually poison anyone. I cannot, however, omit to mention that I think the small quantity swallowed may have materially complicated the after symptoms in the case of some of the survivors.

### Is the Contamination caused by the Sewage from the Metropolitan Outfalls?

4. The question as to the cause of the contamination seems to me to be answered more readily by looking at it from an engineering point of view rather than from a chemical one. The chemical and microscopical analyses show contamination with actual sewage matter as far up as Billingsgate. It is obvious, therefore, that it would be useless to look in Woolwich Reach itself for any specific evidence of contamination which could be considered as coming solely from the North Woolwich outfall, because, having once shown that sewage matter does work up stream a distance of some miles, we are bound to admit the possibility of the sewage matter from the northern outfall working up so as to cause contamination or deposits in Woolwich Reach; but, taking the relative sizes and populations of the districts drained by the North Woolwich sewer and by the Barking and Crossness outfalls together, I think it will be found that the population whose sewage passes through the North Woolwich outfall is not more than about one thousandth of the population whose sewage passes from Barking and Crossness. Assuming, therefore, that all passed into the river at the same point, it would be perfectly legitimate to contend that $\frac{999}{1000}$ of the contamination was due to the larger outfalls, and only one thousandth to the North Woolwich outfall; and it appears to me that the slight difference in position of the outfalls does not sensibly affect this argument.

### Additional Report on Samples from Beckton Gasworks Outfall.

On the 19th October instant I received from Mr. Thomas two more samples, one of which was water taken from the outfall of the Beckton Gasworks, and the other was a sample of mud taken from the foreshore between the gasworks and northern outfall.

The water from the gasworks outfall was simply an admixture of sewage and salt water. The microscope showed the presence of muscular tissue, cotton filaments in large quantity, many hairs both animal and vegetable, and fragments of cooked farinaceous food. This outfall is, therefore, clearly a source of contamination.

The sample of mud from the foreshore between the gasworks and the northern outfall gave the following results on the dried mud:—

| | |
|---|---|
| Organic matter | 15·5 per cent. |
| Mineral matter | 84·5 ,, |
| | 100·0 |

The microscope showed that the organic matter was derived from sewage, since it contained animal and vegetable hairs, and pieces of muscular fibre. The sample had an offensive smell, and effervesced strongly with acids, giving off a strong smell of sulphuretted hydrogen.

We have therefore one proof that, as regards this particular part of the river, the sewage matter does deposit on the bank.

I am, &c.,
G. W. Wigner, F.C.S.

79, Great Tower Street, E.C.,
22nd October 1878.

TABULAR STATEMENT of RESULTS of ANALYSES of SAMPLES of THAMES WATER, taken on the 14th of October 1878.

All results expressed in grains per gallon.

| Place | Billingsgate. | | Limehouse Reach. | | Charlton Pier. | | North Woolwich Pier. | | Wreck at Powder Magazine. | | | Northern Outfall. | Between Northern and Southern Outfalls. | | Southern Outfall. | Jenning-tree Point. | | Gasworks Outfall. (19th Oct.) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | 3 p.m. | | 3.35 p.m. | | 4.40 p.m. | | 4.45 p.m. | | 5 p.m. | | | 5.10 p.m. | 5.20 p.m. | | 5.30 p.m. | 5.40 p.m. | | 3 p.m. |
| Number of Sample | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 11 | 9 | 10 | 12 | 13 | 14 | 15 | 17 | 16 | 18 |
| Depth | Surface | 15 feet | Surface | 20 feet | Surface | 20 feet | Surface | 20 feet | Surface | 20 feet | 40 feet | 5 feet | Surface | 20 feet | 10 feet | Surface | 20 feet | Surface |
| Temperature | 56° | 56½° | 58° | 58° | 56¼° | 56½° | 56° | 56¼° | 55¼° | 56° | 56° | 58° | 55° | 56° | 57° | 56° | 56¼° | — |
| Appearance of Sample | Turbid | Turbid | Turbid | Turbid | Turbid | Turbid | Turbid | Turbid | Turbid | Turbid | Turbid | Very turbid | Turbid | Turbid | Very turbid | Turbid | Turbid | Turbid |
| Smell | Slight | Slight | Slight | Slight | Objection-able. | Objection-able. | Most objection-able. | Sulphur-etted hydrogen. | Most offensive. | Most offensive. | Most offensive. | Decomposed sewage. | Decomposed sewage. | Decomposed sewage. | Decomposed sewage, excessively strong. | Very offensive. | Very offensive. | Offensive |
| Suspended Matter: | | | | | | | | | | | | | | | | | | |
| Organic Matter | 1·24 | 3·01 | 1·26 | 1·83 | 1·58 | 1·17 | ·78 | ·82 | 1·61 | 1·06 | 4·90 | 6·98 | 2·41 | 5·19 | 4·70 | 1·73 | 6·58 | 3·62 |
| Inorganic „ | 6·12 | 13·33 | 5·82 | 6·98 | 4·91 | 5·35 | 5·47 | 5·96 | 4·23 | 4·77 | 27·42 | 17·78 | 10·11 | 24·51 | 12·23 | 8·87 | 27·59 | 9·99 |
| Total suspended or Sedimentary Matter. | 7·36 | 16·34 | 7·08 | 8·81 | 6·49 | 6·52 | 6·25 | 6·78 | 5·84 | 5·83 | 32·32 | 24·76 | 12·52 | 29·70 | 16·93 | 10·60 | 34·17 | 13·61 |
| Colour of Filtered Water | Yellow-brown. | Yellow-brown. | Yellow-brown. | Yellow-brown. | Yellow-brown. | Yellow-brown. | Yellow-brown. | Yellow-brown. | Yellow-brown. | Brown-yellow. | Yellow | Deep yellow-brown. | Urine yellow. | Yellow | Very deep urine yellow. | Yellow-brown. | Urine yellow. | Yellow |
| Dissolved Matter: | | | | | | | | | | | | | | | | | | |
| Organic Matter | 30·40 | 35·80 | 516·00 | 134·20 | 361·80 | 154·00 | 151·60 | 211·20 | 140·40 | 212·20 | 125·20 | 170·00 | 156·80 | 116·00 | 116·20 | 164·00 | 185·00 | 78·40 |
| Mineral „ | 229·40 | 250·80 | 476·80 | 496·00 | 647·20 | 686·00 | 670·20 | 733·20 | 723·40 | 778·60 | 815·20 | 692·40 | 743·00 | 766·60 | 587·00 | 839·80 | 927·60 | 367·20 |
| Total Solid „ | 259·80 | 286·60 | 992·80 | 630·20 | 1009·00 | 840·00 | 821·80 | 944·40 | 863·80 | 990·80 | 940·40 | 862·40 | 899·80 | 882·60 | 703·20 | 1003·80 | 1112·60 | 445·60 |
| Chlorine | 127·98 | 141·64 | 273·35 | 273·35 | 366·53 | 388·90 | 383·93 | 413·83 | 419·94 | 442·32 | 452·26 | 400·08 | 424·93 | 447·30 | 342·93 | 484·57 | 536·76 | 211·23 |
| = Chloride of Sodium | 210·90 | 233·42 | 450·45 | 450·45 | 604·01 | 640·87 | 632·68 | 681·95 | 692·02 | 728·91 | 745·29 | 659·29 | 700·24 | 737·10 | 565·11 | 798·52 | 884·52 | 348·07 |
| Anhydrous Sulphuric Acid. | 16·05 | 17·77 | 32·19 | 33·73 | 43·52 | 47·13 | 45·36 | 47·47 | 49·19 | 52·11 | 52·60 | 28·07 | 50·36 | 49·87 | 40·60 | 21·20 | 16·05 | 23·34 |
| Nitrogen as free and saline ammonia. | ·0140 | ·0260 | ·0440 | ·0440 | ·0740 | ·0700 | ·0620 | ·0500 | ·0400 | ·0600 | ·0500 | ·2000 | ·0255 | ·0315 | ·1900 | ·0680 | ·1400 | ·1200 |
| Nitrogen as albuminoid (organic) ammonia. | ·0100 | ·0120 | ·0160 | ·0180 | ·0200 | ·0200 | ·0160 | ·0180 | ·0160 | ·0500 | ·0240 | ·0620 | ·0070 | ·0070 | ·1100 | ·0160 | ·0500 | ·0120 |
| Oxygen absorbed from a standard solution of permanganate of potash. | ·1700 | ·2002 | ·1700 | ·1550 | ·1500 | ·1400 | ·1350 | ·1650 | ·0850 | ·0850 | ·2195 | ·2850 | ·1750 | ·1800 | ·3650 | ·1000 | ·1500 | ·1675 |

# APPENDIX P.



EXTRACTS FROM REPORTS TO THE COURT OF COMMON COUNCIL OF THE CITY OF LONDON FROM THE PORT SANITARY COMMITTEE.

## THAMES OUTFALLS.

REPORT to the COURT OF COMMON COUNCIL, from the PORT SANITARY COMMITTEE, presented 15th December 1881.

Ellis, Mayor.

A Common Council holden in the Chamber of the Guildhall of the City of London, on Thursday, the 15th day of December, 1881.

The Port of London Sanitary Committee did this day deliver into this Court a Report in writing under their hands, on the reference of the 6th October 1881 to inquire into the sanitary condition of the River Thames in the neighbourhood of Crossness and other outfalls, and to report what steps should be taken to remedy any existing evils thereat, with authority to confer with Her Majesty's Government thereon, and recommending that application be made to the Home Secretary to take action under the provisions of the 21st and 22nd Vict. cap. 104. sect. 31, which was read.

Resolved, that the consideration thereof be adjourned, and it is ordered that the Report be printed, and a copy sent to every member of this Court.

MONCKTON.

To the Right Honourable the Lord Mayor, Aldermen, and Commons of the City of London in Common Council assembled.

WE whose names are hereunto subscribed, of your Port of London Sanitary Committee, to whom on the sixth day of October 1881 it was referred to inquire into the sanitary condition of the River Thames in the neighbourhood of Crossness and other outfalls, and to report what steps should be taken to remedy any existing evils thereat, with authority to confer with Her Majesty's Government thereon, do certify that we have duly proceeded therein, and appointed a Sub-committee, consisting of 18 members of your Committee, to proceed down the river, and themselves take samples of the water at the points referred to in the reference, viz., at Crossness and other outfalls.

Our Sub-committee have since reported to us that on the 23rd November and the 3rd December they proceeded to the points in question, inspecting on the former date and taking samples of the lower part of the river, viz., from Gravesend to Woolwich, and on the latter date of the upper part, viz., high as Teddington Lock. They then instructed our medical officer of health, Dr. Collingridge, to make analyses of the water obtained by them, and report fully thereon.

By direction of your Committee they also instructed Dr. Collingridge to engage the services of Professor Wanklyn, to make independent analyses of the water in question.

The respective analyses of these gentlemen have been made, and reports thereon laid before and carefully considered by your Committee, and are appended hereto for the information of your Honourable Court.

In the minds of your Committee there can be no doubt that the action of the Metropolitan Board of Works under the Metropolis Local Management Act, in taking the sewage of the metropolis down the river to Crossness and Barking Creek, has materially benefited that part of the Thames immediately adjacent to London; but equally without doubt the state of the river at these points, although, being greatly affected by constant meteorological changes, it must of necessity vary from time to time, is, in consequence of the great outpouring of sewage, always in a condition most unsanitary, and that in hot weather in times of drought and great heat its very prejudicial effect upon the public health is obvious, and bearing in mind the fact that the quantity of sewage has of late years enormously increased, and is constantly increasing, your Committee feel that the time has arrived when some definite action should be taken in the matter, and therefore after full consideration deem it expedient that the Corporation should avail itself of the step which, by the Metropolis Local Management Act, 1858, cap. 104, sect. 31, appears open for it to adopt.

This section is as follows, viz.: "It shall be lawful "for one of Her Majesty's Principal Secretaries of "State, at his discretion, on representation or com- "plaint made to him of any nuisance committed in "or execution of any works, or in deodorizing any "sewage, or disposing of any sewage or refuse from "sewers, or in any other manner under this Act, to "cause inquiry to be made into the matter represented "or complained of to him, and to direct such prose- "cutions or to take such other proceedings as he may "think fit, in order to insure the prevention or abate- "ment of such nuisance as aforesaid;" and we accordingly recommend that we should be authorised to apply to the Secretary of State, with the view, under this section of the Act, of remedying the evils complained of.

Your Committee would here add that as the Metropolitan Board of Works are about to extend the sum of 160,000*l.* in enlarging the outfalls works both at Crossness and Barking, the recommendation of your Committee should in our opinion be adopted by your Honourable Court and carried into effect at as early a date as possible.

All which we submit to the judgment of this Honourable Court.

Dated this 14th day of December 1881.

WALTER LOW.
EDWD. W. ROBERTS.
JOHN CRAWFORD.
WILLIAM WALLFORD.
JOSEPH BRINDLE.
O. H. DAVIS.
FREDK. H. MITCHELL.
CHARLES D. MILLER.
JOHN HY. SKILBECK.
ROB. W. CARDEN.
JAMES CRISPE.
WILL. JAS. SCOTT.
J. LAIDLAW CROSS.
W. T. GIBSON.

*(Here follows a Report from Dr. Collingridge, dated 8th December* 1881, *for which see his evidence.)*

EXTRACTS from a subsequent REPORT of the PORT OF LONDON SANITARY COMMITTEE, 16th March 1882.

To the Right Honourable the Lord Mayor, Aldermen, and Commons of the City of London, in Common Council assembled.

WE whose names are hereunto subscribed of your Port of London Sanitary Committee, to whom it was referred to carry into execution the Public Health Acts, 1872 and 1875, beg to submit for your consideration the Half-yearly Report of William Collingridge, Esq., M.B., the medical officer of health of the port of London, for the half-year ending the 31st December 1881, which report contains a full and detailed statement of the work done during that period in the port of London by the medical officer and the inspectors.

The report also calls attention to the condition of the water in the river, which must, whilst the sewage of the metropolis is passed into the river, be a source of great anxiety to all concerned in the health of those engaged thereon.

The special report of the medical officer of health on this subject, appended to our report, agreed to by your Honourable Court on the 19th January last, is annexed to the report of Dr. Collingridge now presented, and your Committee would here state that, under the reference from your Honourable Court of the 19th January last, to carry into execution our report upon the "Thames Outfalls," energetic measures are being taken with a view to alleviate the existing evils in this respect.

*(Here follows Report of Dr. Collingridge, dated 4th January* 1882, *for which see his evidence.)*

App. Q.

## APPENDIX Q.

MEMORIAL FROM THE VESTRY OF PLUMSTEAD.

To the Right Honourable BARON BRAMWELL and others Her Majesty's Commissioners. Upon the subject of the Pollution of the River Thames.

THE MEMORIAL OF THE VESTRY OF PLUMSTEAD, IN THE COUNTY OF KENT,

SHOWETH,

"1. That by the Metropolis Local Management Act, 1855, sec. 135, the Metropolitan Board of Works were directed to prevent the sewage of London from flowing into the River Thames in or near the Metropolis.

"2. That the said Board has constructed huge outfalls at Barking and Crossness, whereby the sewage in immense quantities is discharged into the river, both in and near the Metropolis, to the great detriment of the public health, and in entire contravention of the said Act.

"3. Long before 1855, and ever since, it was never contemplated by the Legislature that the said Board would so flagrantly act in violation of their public duty, or that the said sewage would be dealt with in any other way than by a very distant removal of it from the Metropolis.

"4. In 1865 a Select Committee of the House of Commons took exhaustive evidence upon the subject, and in that and the following years two Acts were passed for the purpose of enabling the sewage at Barking to be carried right out to the Maplin Sands; and your memorialists respectfully urge that the Royal Commission should read that evidence and those Acts, and investigate the reasons why the salutary recommendations of the House of Commons contained therein were not carried out; and they earnestly request that you should examine Colonel Hope and the Secretary of the Stock Exchange upon the subject, and make them produce all the papers they have in relation thereto.

"5. So far as your memorialists have been able to ascertain, no good reason has ever been given why such recommendations have not been carried out.

"6. Some years ago the Native Guano Company spent upwards of 30,000*l.* in creating a clear effluent out of the sewage at Crossness, but your memorialists are informed that the said Board caused the Company's works to be suddenly stopped and blown up with gunpowder, and no good reason has ever been given for this extraordinary conduct, and your memorialists consider that this ought to be made a subject of close inquiry by the Royal Commission, and your memorialists hope that the officers of the Company and of the Board will be examined upon the whole question.

"7. It is not improbable that by a combination of the recommendations of Parliament in 1865, with some such system as that tried at Crossness, the river could be successfully saved from the pollution which is at present created.

"8. In 1878 nearly 800 persons were drowned in the river within the parish of Plumstead, and much of the evidence on the coroner's inquest went to show that many of them were poisoned or suffocated by the foul sewage in the river.

"9. Mr. Carttar, the coroner for this district, can give important evidence as to the number of deaths that have since arisen from this cause.

"10. The parochial medical officers' report shows fever to be very prevalent in the parish, and at low tide the mud of the river shore is infested with living organisms visible to the naked eye.

"11. Mr. T. N. Moors and Mr. George Webb, members of the vestry of Plumstead, and residents in the parish, can also give some evidence as to the foulness of the river, and its effects.

"12. Mr. Mellniss, a civil engineer, of Gresham House, in the city of London, has informed your memorialists that he has given great study to the question, and is in a position to give useful evidence to the Committee thereon.

"13. Your memorialists consider that some economical and efficient means ought to be adopted for speedily ridding the river of the sewage, and turning it into a profitable manure for the land.

"Your memorialists therefore respectfully and earnestly beg that the above-mentioned persons may be heard and examined by you before you report upon the subject of the Pollution of the River Thames to her Majesty."

J. MCALLISTER,
3rd November 1882. Chairman.

App. R.

## APPENDIX R.

REPORT on the OBSERVATIONS made in the RIVER THAMES for the CORPORATION of the CITY of LONDON, acting as the PORT of LONDON SANITARY AUTHORITY, in reference to the DISCHARGE of SEWAGE from the METROPOLITAN OUTFALLS. By BALDWIN LATHAM, M. Inst. C.E., F.G.S., F.M.S., 7, Westminster Chambers, Westminster, S.W., January 1883.

(*Put in by Mr. Latham, 23rd January* 1883.)

IN the investigations made to ascertain the influence of the discharge of sewage at Barking, Crossness, and other places, into the tidal channel of the River Thames, it has been deemed advisable to prepare a careful survey of the river, and to make a number of sections in order to ascertain its tidal capacity, and the relative sectional area at every portion of its course at mean tide level. This part of the work has been entrusted to Mr. James Mansergh, M. Inst. C.E., and Mr. Chas. J. More, M. Inst. C. E.

In order to accurately determine the range of oscillation about the point of the Northern Outfall at Barking, a series of float observations have been undertaken, and to ascertain the vertical range of the tides, self-recording tide gauges have been erected, or the observations from those already in existence have been procured, so as to obtain a complete knowledge of the tidal phenomena in the river.

During the whole of the period that the tidal observations have been going on, a series of actual gaugings of the streams of water flowing into the tidal portion of the river below Teddington Lock have been made at the following places:—

The River Thames at Teddington.
Stream entering the Thames at Strawberry Hill.
Stream passing through Twickenham.
The River Crane at Isleworth.
The River Brent and Grand Junction Canal.
A stream entering at Chiswick called the "Duke's Ditch."
The Beverley Brook.
The River Wandle.
The Regent's Canal and Limehouse Cut.
The River Ravensbourne.
The River Lea.
The River Roding and its branches.
Mayes Brook and its tributaries.
A stream entering at Horse Shoe Corner.
The River Beam and stream between Rivers Beam and Ingreborne.

River Ingreborne.
Stream entering at Erith Reach, and streams at Wennington.
Mar Dyke.
The River Cray and its tributary.
The River Darent.
The Grays Chalk Quarries.
Streams at Northfleet, Chadwell St. Mary, and Tilbury.
Streams at Gravesend Reach, Higham, Mucking Creek, and Higham Creek.
Streams at Stanford-le-Hope and north of Stanford-le-Hope.
Streams at Fobbing and north of Fobbing.
Vange Wharf and Stream.
Stream at Pitsea Creek.
Streams at Cooling.
Wall End, Barking.

In the whole, actual gaugings have been taken at 50 stations, and the area not gauged, including the area of the river and part of the metropolis, is 284 square miles, from which an estimated amount of surface and spring water has been calculated as finding its way into the river during the course of these experiments. The area calculated in this way forms but the $\frac{1}{18}$th part of the whole catchment basin of the Thames. The volume of water-supply, taken from Colonel Bolton's returns, is also added, as all this water naturally belongs to the Thames Basin, and after use is again returned to the river.

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### Tidal Experiments.

A series of float experiments were undertaken in order to accurately ascertain the tidal range in the River Thames, or the distance at various periods at which matters floating in the river would pass backwards and forwards with the ebbing and flowing tide.

The floats used in these experiments, numbered 1 to 8, were of a massive character, being 12 feet 6 inches in length, weighted at the bottom end so as to swim in a vertical position, and constructed of solid timber 11½ inches in diameter, and were immersed 12 feet in the water. The floats were of an octagonal form so as to offer at every position nearly the same surface of exposure to the action of the current in the river.

Seven distinct sets of observations were made with these floats on the range of the tides. The floats were put into the river at various periods of tidal flow, for example, the first three floats were placed in the river on the 14th September 1882, being the period of spring tide, No. 1 float being placed in at high water, No. 2 float three hours after high water, and No. 3 float at low water. Nos. 4, 5, and 6 floats were placed in the river on the 22nd September, being the period of neap tide, No. 4 float being placed in at high water, No. 5 float three hours after high water, and No. 6 at low water. It being found on the 5th October that Nos. 3 and 5 floats were in close proximity to each other, No. 5 float was taken out of the river and re-started as No. 7 float, being placed in the river at half flood tide on the 6th October at the period of neap tide.

The eighth experiment was made with a float 4 feet deep, 11½ inches diameter, weighted at the bottom and floating 4 inches out of the water. It was started in the river below Teddington Weir, in the afternoon of the 27th October, and was allowed to take its course down the river.

The ninth experiment consisted in making simultaneous observations in the river in different parts with floats of a similar character to those used in the observations No. 1 to 7, for which purpose the floats were put in the river at high water, and were allowed to flow down and up with the current.

In the tenth experiment two sets of floats were used, or surface floats and deep floats. The surface floats were constructed of a wooden ball 1 foot diameter, and were used to test the relative rate of velocity between them and the deeper floats. Another important object of this experiment was to ascertain, by means of samples of water, what degree of admixture of the upland and sea-water took place in the river during the ebb and flow of the tide.

The floats Nos. 1 to 7 were watched night and day by two men in a rowing boat, and the boats were under constant inspection by the observers in the steam-tug "Toby," which had been specially retained for the purpose. The float observations were carried out under my instruction, and were from time to time inspected by me; but in order to ensure the greatest accuracy they were placed under the personal care of Mr. R. W. Peregrine Birch, M. Inst. C.E., who took up his quarters, during the period of observation, on board the steam-tug.

Although the experiments were started at high water at spring tide on the 14th September 1882, owing to a fog on the night of that day, and the men not being thoroughly conversant with the work, the first start proved abortive, and it was not until the 17th September that the experiments fairly commenced.

The following particulars will show the various points of importance with reference to the movement of the floats in the river.

#### *No. 1 Float.*

No. 1 float was put into the centre of the River Thames at high water, opposite the Metropolitan Northern Outfall Sewer at Barking, at 4h. 25m. P.M. on the 17th September 1882. The tides at this period were "taking off," high spring tide having occurred on the 14th September. On the ebb tide the float descended as far as Denton Wharf, 15·84 miles below the point at which it was put in. On the returning tide, on the morning of the 18th September, the float reascended the river to a point in Halfway Reach 2·77 miles below the Northern Outfall Sewer, and in the afternoon of the same day, at high water, it reached a point 2·14 miles below the Northern Outfall Sewer, and so the float progressed backwards and forwards in the river, until at low water at noon on the 20th September it reached a point in Gravesend Reach 16·73 miles below where it was inserted, being about a quarter of a mile above Shorne Mead Battery. On the afternoon of the 22nd September, being the period of neap tide, the float at high water was at a point in Long Reach 7·65 miles below the Northern Outfall Sewer, and at low water on the morning of the 23rd September it was near Coal House Point, 17·56 miles below the Northern Outfall Sewer. On the morning of the 24th September, at low water, the float had reached a point 18·32 miles below the Northern Outfall Sewer, and at high water on the night of the 24th September it was in Erith Reach, 3·92 miles below the Northern Outfall Sewer. Early in the morning of the 27th September, at high water, the float had ascended the river to a point 0·65 of a mile above the Northern Outfall Sewer, and on the following low water it had reached a point in Gravesend Reach 13·37 miles below the Northern Outfall Sewer. On the morning of the 29th September, being the period of high spring tide, the float had reached a point in Woolwich Reach, 2·08 miles above the Northern Outfall Sewer, and at low water on the following tide it had descended to a point in the lower part of Northfleet Hope, 13·10 miles below the Northern Outfall Sewer. On the morning of the 1st October, at high water, the float was 0·05 of a mile below the Northern Outfall Sewer, and at low water on the morning tide of the same day it had reached a point in Gravesend Reach 15·38 miles below the Northern Outfall Sewer. On the morning of the 4th October, at high water the float was in Long Reach, 7·13 miles below the Northern Outfall Sewer, and at low water on the same day it was in Gravesend Reach, 17·36 miles below the Northern Outfall Sewer. On the afternoon of the 6th October, being the period of neap tide, at high water the float was off the Leather Bottle, 1·66 miles below the Northern Outfall Sewer, and at low water in the morning of the 7th October it was in Northfleet Hope, 13·00 miles below the Northern Outfall Sewer. At high water on the morning of the 12th October the float was off the Leather Bottle, 1·62 miles below the Northern Outfall Sewer, and at low water on the same morning it was at a point off Rosherville, 13·87 miles below the Northern Outfall Sewer. On the 13th October, at high water on the morning tide, the float was in Halfway Reach 1·76 miles below the Northern Outfall Sewer, and about two hours after the return of the float down the river a fog came on, and the float was lost. At noon the same day it was again started in a position with reference to No. 4 float, which had been continuously working during the period, similar to that which it had occupied on the previous tide, and in the afternoon, on the first tide, after being so started, it had reached a point at high water in Halfway Reach, 2·22 miles below the Northern Outfall Sewer, and at low water in the afternoon of the same day it had reached a point in Gravesend Reach, 17·50 miles below the Northern

App. R.

Outfall Sewer. On the morning of the 14th October, being the period of high water spring tide, at high water the float was in Halfway Reach, 2·20 miles below the Northern Outfall Sewer. On the morning of the 16th October, at high water, the float was 2·00 miles below the Northern Outfall Sewer, being opposite the Metropolitan Southern Outfall Sewer at Crossness, and at low water on the same morning it was in Gravesend Reach, 13·63 miles below the Northern Outfall Sewer. On the succeeding flood tide the float made considerable progress up the river, so that at high water on the afternoon tide it was in Woolwich Reach, 2·00 miles above the Northern Outfall Sewer, and on the high-water morning tide of the 17th October the float had reached a point in Greenwich Reach 6·56 miles above the Northern Outfall Sewer, and at low water had descended to a point in Long Reach 6·62 miles below the Northern Outfall Sewer. At high water on the succeeding tide the float descended somewhat lower, being in Blackwall Reach, 5·52 miles above the Northern Outfall Sewer, after which it gradually descended, so that at high water on the morning of the 19th October it was in Woolwich Reach, 2·75 miles above the Northern Outfall Sewer. On the morning tide of the 21st October, being the period of neap tide, at high water the float had descended to a point in Barking Reach, 1·13 miles below the Northern Outfall Sewer, and at low water in the afternoon of the same day it had reached a point in Fiddler's Reach 10·20 miles below the Northern Outfall Sewer. On the morning of the 22nd October, at high water, the float had reached a point in Halfway Reach 1·56 miles below the Northern Outfall Sewer, and in the afternoon of the same day, at low water, it was in Northfleet Hope, 11·60 miles below the Northern Outfall Sewer. At high water on the morning of the 24th October the float was in Halfway Reach, 2·15 miles below the Northern Outfall Sewer. Shortly after high water a gale came on, rending it impossible to observe the floats in this part of the river, so that the experiment was discontinued until the afternoon of the 25th October, when the float was again put into the river at low water, in exactly the same position as it had occupied at low water on the morning tide of the 24th October. At high water on the early morning of the 26th October the float had reached a point in Woolwich Reach, 2·00 miles above the Northern Outfall Sewer, after which it was again lost in a fog, and to continue the experiment, the float was again put into the river at high water on the afternoon tide of the same day, and at the same spot at which it had reached at high water on that morning previous to its being lost in the fog. It descended the river on the ebb tide to a point in Northfleet Hope, 12·08 miles below the Northern Outfall Sewer, and on the succeeding flood tide reascended the river to a point in Blackwall Reach 5·22 miles above the Northern Outfall Sewer. On the morning of the 28th October, being the period of spring tide, the float at high water had reached a point in Greenwich Reach, 7·23 miles above the Northern Outfall Sewer. In the evening of the same day a gale came on, and the experiment was discontinued until the afternoon of the 29th October, when the float was again put into the river, at a point 0·42 of a mile below the position which it occupied at high water in the afternoon of the 28th October. On the ebb tide it descended to a point in Fiddler's Reach 10·55 miles below the Northern Outfall Sewer, and reascended on the flood tide to a point in Woolwich Reach, 2·10 miles above the Northern Outfall Sewer. On the morning of the 1st November the float had reached a point in Halfway Reach 2·20 miles below the Northern Outfall Sewer, and at low water the same morning it was at a point in Gravesend Reach, 17·45 miles below the Northern Outfall Sewer. The float again ascended the river, but a heavy gale having arisen, the experiment was stopped.

It will be observed that, in the forty-five days this float had been in the river, it only made a progress of 2·20 miles down it, that is upon the assumption when there was a break in the experiment, the float was reinserted in its proper position with reference to the former experiment, but it will be seen from the diagrams that these corrections are rather favourable than otherwise to the descent of the float down the river. In two complete lunations, or to the morning of the 16th October, the float had descended 2·00 miles down the river. It will also be observed that in the twenty-six days in which there was no break in the experiments, that is, between the 17th September and the 13th October, the float had only progressed down the river 1·76 miles from the point at which it was inserted opposite the Northern Outfall Sewer.

*No. 2 Float.*

No. 2 float was put into the centre of the river, opposite the Northern Outfall Sewer at Barking, at 7h. 25m. P.M. on the 17th September 1882, being three hours after high water. On the ebbing tide it descended to a point below Purfleet Wharf, being 7·40 miles below the Northern Outfall Sewer. On the next flood tide, on the morning of the 18th September, it ascended the river to a point opposite Greenwich Station, being 6·75 miles above the Northern Outfall Sewer. On the morning tide of the 20th September, at high water, the float was 1·95 miles above the Northern Outfall Sewer, and at low water at noon the same day it was 7·85 miles below the Northern Outfall Sewer. Subsequently the float progressed backwards and forwards, so that at high water on the morning of the 22nd September, being the period of neap tide, it was 3·10 miles above the Northern Outfall Sewer, and at low water in the afternoon of the same day it was 6·82 miles below the Northern Outfall Sewer. On the morning tide of the 23rd September, at high water, the float was but 0·30 of a mile above the Northern Outfall Sewer, and at low water on the same day it was 10·18 miles below the Northern Outfall Sewer. On the morning of the 24th September, at low water, it was 10·15 miles below the Northern Outfall Sewer, and at high water the same day it was exactly opposite the point at which it was put in on the 17th instant, or at the Northern Outfall Sewer. At high water in the afternoon tide of the 27th September the float had reached a point 5·82 miles above the Northern Outfall Sewer, and at low water in the afternoon of the same day it was 10·58 miles below the Northern Outfall Sewer. On the morning of the 29th September, being the period of high water spring tide, the float had reached a point opposite Greenwich Hospital, or 6·64 miles above the Northern Outfall Sewer, and at low water in the morning of the same day it was 6·60 miles below the Northern Outfall Sewer. At high water in the afternoon of the 30th September, the float had reached a point 9·90 miles above the Northern Outfall Sewer, being just below the point of crossing of the Thames Tunnel, and at low water in the night of the same day it had reached a point 7·10 miles below the Northern Outfall Sewer, being opposite Purfleet Wharf. On the morning of the 1st October, at high water, the float was 8·92 miles above the Northern Outfall Sewer, being in the upper portion of Limehouse Reach, and at low water on the morning of the same day it was 6·18 miles below the Northern Outfall Sewer. At high water in the afternoon tide of the same day the float had reached a point 9·70 miles above the Northern Outfall Sewer, and on the following low water descended to a point 5·60 miles below the Northern Outfall Sewer. On the morning of the 4th October, at high water, the float was 1 mile above the Northern Outfall Sewer, and just after noon on the same day, at low water, it was in the lower part of Long Reach, or 9·28 miles below the Northern Outfall Sewer. In the afternoon of the 6th October, being the period of neap tide, at high water the float was 4 miles above the Northern Outfall Sewer, and on the succeeding low water, on the morning of the 7th October, it was 6·15 miles below the Northern Outfall Sewer. On the early morning of the 10th October the float had reached a point at high water 4·40 miles above the Northern Outfall Sewer, and when descending upon the morning tide of that day it was lost sight of in the fog, and was found again near Erith Pier upon the ascending tide. The float was seen at 7 A.M., at low water, opposite the West Kent Outfall, so that there is every probability that it ran its full course. On the succeeding high water of the same day the float had reached a point above Bow Creek, or 5 miles above the Northern Outfall Sewer, and at low water on the following tide reached a point 7·80 miles below the Northern Outfall Sewer, being rather lower than the position of the West Kent Outfall into the Thames. At high water on the morning of the 12th October the float had reached a point in Greenwich Reach, 7·15 miles above the Northern Outfall, and at the following low water, in the morning of the same day, it had reached a point 7·14 miles below the Northern Outfall Sewer, being a little below Purfleet Wharf. On the morning of the 14th October, being the period of high water spring tide, the float was 6 miles above the Northern Outfall Sewer, and at low water on the following tide was 8·90 miles below the

Northern Outfall Sewer. On the morning of the 16th October, at high water, the float was 6·62 miles above the Northern Outfall Sewer, and at the following low water it was 6·15 miles below the Northern Outfall Sewer. At high water in the afternoon of the same day it had ascended the river to a point 8·08 miles above the Northern Outfall Sewer, or to Limehouse Reach, just above Millwall Docks. On the afternoon of the 17th October the float had reached, at high water, a point in Limehouse Reach, 8·25 miles above the Northern Outfall Sewer. At low water on the morning of the 18th October the float had descended to a point at Crayford-Ness, 6·10 miles below the Northern Outfall Sewer, and on the succeeding high water, in the afternoon of the same day, it had ascended to Blackwall Reach, at a point 5·45 miles above the Northern Outfall Sewer. The float again descended the river, but some time afterwards a fog came on and the float was lost.

It will be observed that, calculating from the high water of the tide following that on which the float was inserted in the river, in thirty-one days the observations were going on, the float advanced 1·30 miles down the river in the high water periods, or from 6.75 miles above the Northern Outfall Sewer to 5·45 miles above it. At the end of the two periods of lunation, ending on the 16th October, the float had ascended 1·33 miles up the river.

*No. 3 Float.*

No. 3 float was put into the centre of the river opposite the Northern Outfall Sewer, at low water, at 11h. 40m. P.M. on the night of the 17th September 1882. On the ascending tide at high water, on the morning of the 18th September, it had reached Lambeth Bridge, being 13·90 miles above the point at which it was put in the river. At low water, on the following tide, it had reached a point 0·75 of a mile above the Northern Outfall Sewer. At high water, in the afternoon of the 20th September, the float had reached Chelsea Bridge, being 16·62 miles above the Northern Outfall Sewer, and at low water on the following tide, in the early morning of the 21st September, it had reached a point 5·30 miles above the Northern Outfall Sewer. In the afternoon of the 22nd September, being the period of neap tide, the float at high water was above Vauxhall Bridge, or 14·65 miles above the Northern Outfall Sewer, and at low water on the succeeding tide, in the morning of the 23rd September, it was 3·90 miles above the Northern Outfall Sewer. At low water, on the afternoon of the 23rd September, it had reached a point 2·95 miles above the Northern Outfall Sewer. On the morning of the 24th September, at low water, the float was 2·95 miles above the Northern Outfall Sewer, being opposite the Upper Ferry at Woolwich, and at high water, on the succeeding tide, it was at Westminster Bridge, or 13·37 miles above the Northern Outfall Sewer. On the early morning of the 26th September, at high water, the float was below Chelsea Bridge or 16·50 miles above the Northern Outfall Sewer, and at low water, in the morning of the same day, it was 2·95 miles above the Northern Outfall Sewer. On the early morning of the 27th September, the float had reached a point 18·55 miles above the Northern Outfall Sewer, and at low water, in the morning of the same day, it was 4·70 miles above the Northern Outfall Sewer. On the morning tide of the 29th September, being the period of high spring tide, the float had reached a point 21·68 miles above the Northern Outfall Sewer, being opposite Messrs. Thorneycroft's works at Chiswick. At the following low water, in the morning of the same day, the float was in Greenwich Reach, or 6·62 miles above the Northern Outfall Sewer. In the afternoon of the 1st October, the float at high water was 19·20 miles above the Northern Outfall Sewer, being above Putney Bridge, and at low water on the succeeding tide had reached a point 4·70 miles above the Northern Outfall Sewer. On the morning tide of the 4th October, at high water, the float was 15·45 miles above the Northern Outfall Sewer, and on the succeeding low water of the same day it was 3·82 miles above the Northern Outfall Sewer. In the afternoon of the 6th October, being the period of neap tide, at high water, the float was 15·40 miles above the Northern Outfall Sewer, and on the succeeding low water, in the morning of the 7th October, it was 4·88 miles above the Northern Outfall Sewer. On the afternoon tide of the 12th October, at high water, the float was 19·90 miles above the Northern Outfall Sewer; and on the succeeding low water, on the same night, it was 5·75 miles above the Northern Outfall Sewer. On the next tide, in the morning of the 13th October, at high water, the float was 20 miles above the Northern Outfall Sewer. At low water, in the morning of the same day, the float was in Blackwall Reach, 6·10 miles above the Northern Outfall Sewer. At high water, on the morning of the 14th October, being the period of high water spring tide, the float was 20·15 miles above the Northern Outfall Sewer. On the morning of the 16th October, the float was 17·52 miles above the Northern Outfall Sewer or below Fulham Bridge, and at low water, in the morning of the same day, it was in Bugsby's Reach, or 4·64 miles above the Northern Outfall Sewer. At high water, in the morning of the 17th October, the float was 17·60 miles above the Northern Outfall Sewer, and at low water it was 4·70 miles above the Northern Outfall Sewer. On the following high water, in the afternoon of the 17th October, the float was 15·90 miles above the Northern Outfall Sewer, after which period it continued to descend until, in the afternoon of the 18th October, it reached a point at high water 12·85 miles above the Northern Outfall Sewer. After returning down the river some distance a fog came on, and the float was lost sight of. It was, however, again started on low water in the afternoon of the 19th October, in the same position with reference to No. 7 float (which had not been lost), and which was the nearest float to it, as it had occupied previous to its being lost. At high water, on the afternoon of the 19th October, the float had reached a point 11·00 miles above the Northern Outfall Sewer, being 1·85 miles lower than the high water of the tide preceding that upon which it was lost in the fog. At high water on the morning of the 21st October, being the period of neap tide, the float was 8·00 miles above the Northern Outfall Sewer, and at low water, on the succeeding tide it descended to a point 3·20 miles below the Northern Outfall Sewer. At high water, on the morning of the 22nd October, the float was 6·73 miles above the Northern Outfall Sewer, and at low water, in the afternoon of the same day, it was 3·38 miles below the Northern Outfall Sewer. At low water, on the morning of the 24th October, the float was 6·20 miles below the Northern Outfall Sewer. At 11h. 40m. A.M. at high water, on the same day, the float had reached a point in Greenwich Reach, 6·60 miles above the Northern Outfall Sewer. A gale coming on, the observation was discontinued until high water on the afternoon tide of the 26th October, when the float was put into the river in exactly the same position as it had occupied at high water on the 24th October. The float descended the river on the ebb tide to a point 6·19 miles below the Northern Outfall Sewer, and on the following flood tide, on the early morning of the 27th October, it passed up the river to a point 10·48 miles above the Northern Outfall Sewer. On the morning of the 28th October, being the period of spring tide, at high water the float had reached the Upper Pool, or 10·40 miles above the Northern Outfall Sewer, and at low water, in the morning of the same day, it reached a point 4·45 miles below the Northern Outfall Sewer, being just opposite Erith Church. At high water, in the afternoon of the 29th October, the float was 4·93 miles above the Northern Outfall Sewer, and at low water, on the night of the same day, it reached a point 6·80 miles below the Northern Outfall Sewer. On the morning of the 1st November, at high water, the float had descended to a point 0·30 of a mile below the Northern Outfall Sewer, and at low water on the succeeding tide it reached a point 13·80 miles below the Northern Outfall Sewer. On the following flood tide it ascended the river to a point 2·75 miles below the Northern Outfall Sewer. A gale coming on the experiment was discontinued.

It will be observed that in the forty-three days that this float was in the water, it made a progress from low water to low water of 13·80 miles down the river. It will also be observed that, if we take the thirty-one days in which this float was going backwards and forwards in the river without any interference, at the end of the period it had made no advance down the river, but ascended one mile above the point at which it was inserted. It will also be seen that in the two lunations ending the 16th October, the float had not descended at low water, but had advanced up the river 4·64 miles, and it was not until a large quantity of land water came down the river that the float made any progress seawards.

App. R.

*No. 4 Float.*

No. 4 float was put into the centre of the river opposite the Northern Outfall, at high water, at 7h. 50m. A.M. on the morning of the 22nd September, being the period of neap tide. On the first ebb it descended a distance of 6·95 miles, and on the succeeding flood, on the afternoon of the same day, it reached a point 1·70 miles above the Northern Outfall Sewer. On the morning of the 24th September, at low water, the float had reached a point 11·35 miles below the Northern Outfall Sewer, and on the succeeding high water, on the morning of the same day, it was 2·15 miles below the Northern Outfall Sewer. Early in the morning of the 27th September, at high water, the float was in Woolwich Reach, 2·92 miles above the Northern Outfall Sewer, and on the succeeding low water it had reached a point of 12·85 miles below the Northern Outfall Sewer, or was opposite the Northfleet Mill. On the night of the same day, at low water, it had descended the river to a point 16·10 miles below the Northern Outfall Sewer. On the morning of the 29th September, being the period of high spring tide, at high water the float had reached a point 4·40 miles above the Northern Outfall Sewer, and on the succeeding low water descended to a point 11·75 miles below the Northern Outfall Sewer. On the morning of the 1st October, at high water, the float was 1·00 mile above the Northern Outfall Sewer, and at the succeeding low water was 14·75 miles below the Northern Outfall Sewer. At high water on the morning of the 4th October, the float was 4·00 miles below the Northern Outfall Sewer, and on the succeeding low water was 12·25 miles below the Northern Outfall Sewer. In the afternoon of the 6th October, being the period of neap tide, at high water, the float was 0·20 of a mile above the Northern Outfall Sewer, and on the succeeding low water of the following morning it was 10·65 miles below the Northern Outfall Sewer. At high water on the night of the 7th October, the float was 0·78 of a mile below the Northern Outfall Sewer, and on the early morning of 8th October, it descended down the river and reached a point at low water 10·82 miles below the Northern Outfall Sewer, and reascended on the flood tide to a point 2·13 miles below the Northern Outfall Sewer. On the 10th October, in the early morning, at high water, the float was 2·18 miles below the Northern Outfall Sewer, and in descending the river a fog came on, and the precise position to which the float descended could not be seen; although the observers never lost sight of the float, they were unable to see the shore until the float again returned at high water, when it reached a point 1·10 miles below the Northern Outfall Sewer. At high water on the morning of the 13th October, the float was 0·75 of a mile below the Northern Outfall Sewer, and on the descending tide the float was lost in a fog, but was found on the same tide, just before low water, by the observers in the steam-tug "Toby," and at low water it descended to a point 15·40 miles below the Northern Outfall Sewer. On the return tide in the afternoon of the same day, at high water, the float was 1·50 miles below the Northern Outfall Sewer. On the morning of the 14th October, being the period of high-water spring tide, the float was 0·80 of a mile below the Northern Outfall Sewer, and on the succeeding low water had descended to a point 14·75 miles below the Northern Outfall Sewer. On the morning of the 16th October, at high water, the float was 0·43 of a mile above the Northern Outfall Sewer, and at low water on the same morning it was 10·82 miles below the Northern Outfall Sewer. On the morning tide of the 17th October the float had made considerable progress up the river, so that at high water it was found at a point opposite Greenwich Station, being 6·86 miles above the Northern Outfall Sewer, and on the succeeding low water it was 6·22 miles below the Northern Outfall Sewer. At high water on the morning of the 19th October, the float was 3·99 miles above the Northern Outfall Sewer, and on the succeeding low water was 6·98 miles below the Northern Outfall Sewer. On the morning of the 21st October, being the period of neap tide, at high water, the float had descended to a point 0·65 of a mile below the Northern Outfall Sewer, and on the succeeding low water, in the afternoon of that day, was 9·63 miles below the Northern Outfall Sewer. On the morning of the 22nd October, at high water, the float was 1·40 miles below the Northern Outfall Sewer, and on the succeeding low water of the same day it was at a point 10·93 miles below the Northern Outfall Sewer. At low water in the morning of the 24th October, the float was 14·35 miles below the Northern Outfall Sewer, and on the succeeding high water had reached a point 2·15 miles below the Northern Outfall Sewer, when a gale arose and the observations were for a time suspended. The float was again put into the river at low water, on the afternoon of the 25th October, at the same point at which it had arrived at low water in the morning of the 24th October. It ascended the river, and reached a point, in the early morning of the 26th October, 1·70 miles above the Northern Outfall Sewer, when the float was again lost in a fog. In the afternoon of the same day, at high water, it was put into the river at the same place it had reached in the early morning high water, and descended on the ebbing tide to a point 11·87 miles below the Northern Outfall Sewer, and on the succeeding tide, in the morning of the 27th October, it had reached a point at high water 4·85 miles above the Northern Outfall Sewer. At high water on the morning of the 28th October, being the period of spring tide, the float was just below Millwall Dock entrance, 7·86 miles above the Northern Outfall Sewer, and on the succeeding low water, in the morning of the same day, reached a point in Erith Rands 5·26 miles below the Northern Outfall Sewer. On the succeeding flood tide the float reached a point in Greenwich Reach above the Greenwich Gasworks, 6·98 miles above the Northern Outfall Sewer, when this observation was concluded.

It will be observed that in the 36 days this float was in the river, instead of descending the river, it ascended to a point 6·98 miles above that at which it was inserted It will also be observed that in the 32 days in which there was no break, that is, between the 22nd September and the 24th October, the float had descended but 2·15 miles down the river. It will also be observed that in the two lunations ending the 21st October, on the morning tide of the 21st October the progress down the river had been but 0·65 of a mile, and in the afternoon tide of the same day the position of the float exactly corresponded to that at which it was put in at the commencement of the observations, or was opposite the Northern Outfall Sewer at Barking.

*No. 5 Float.*

No. 5 float was put into the centre of the river, three hours after high water, opposite the Northern Outfall Sewer, at 10h. 50m. in the morning of the 22nd September, being the period of neap tide. On the ebb tide it passed down the river 4·95 miles below the Northern Outfall Sewer, and on the succeeding flood tide reached a point in the upper part of Blackwall Reach, 6·30 miles above the Northern Outfall Sewer. At low water on the morning of the 24th September, the float had reached a point 4·80 miles below the Northern Outfall Sewer, and on the succeeding high water it had travelled to a point 7·15 miles above the Northern Outfall Sewer. At high water on the morning tide of the 27th September. the float had reached a point just below Millbank Pier, 14·20 miles above the Northern Outfall Sewer, and on the succeeding low water descended to a point 0·07 of a mile below the Northern Outfall Sewer. On the morning of the 29th September, being the period of high spring tide, the float had reached Putney Bridge, 18·85 miles above the Northern Outfall Sewer, and at the succeeding low water it was still 3·85 miles above the Northern Outfall Sewer. At high water on the morning of the 1st October, the float had reached a point above Putney Bridge, 19·70 miles above the Northern Outfall Sewer, and on the succeeding low water was in Bugsby's Reach 4·55 miles above the Northern Outfall Sewer. On the morning of the 4th October, the float had reached a point near the Victoria Railway Bridge, 15·40 miles above the Northern Outfall Sewer, and on the succeeding low water, in the afternoon of the same day, it was still 2·45 miles above the Northern Outfall Sewer. At high water on the morning tide of the 5th October, the float was 14·25 miles above the Northern Outfall Sewer, near Millbank Pier, and on the ebb tide it descended the river to a point 4·75 miles above the Northern Outfall Sewer. Shortly after the return of the float upon the flood tide, it was taken out, as it was found that No. 3 float was in such close proximity, it was not worth while to continue two floats running over the same course, and this float was started, after this date, as No. 7 float. The observations which have been made with reference to No. 3 float, after this period, will apply to No. 5 float.

It will be observed that, in the 13 days these observations were going on, counting from high water succeeding the period when the float was put in the

river to the last high water observed, the float had made a progress up the river, in the 13 days, of 7·95 miles.

*No. 6 Float.*

No. 6 float was put into the centre of the river at low water, opposite the Northern Outfall Sewer at 2h. 40m. in the afternoon of the 22nd September, it being the period of neap tide. It was carried by the flood tide to a point 10·18 miles above the Northern Outfall Sewer, and on the succeeding low water in the morning of the 23rd September, it had reached the same position as that at which it was started. On the succeeding flood tide a fog came on and the float was lost sight of; but in the afternoon tide of the same day it was started at a point equivalent to low water at the Northern Outfall Sewer, and on the succeeding high water on the night of the same day, the 23rd September, it had reached a point 11·75 miles above the Northern Outfall Sewer. On the morning of the 24th September, at low water, the float was again at the same position from which it was started, viz., opposite the Northern Outfall Sewer, and on the succeeding high water it reached a point 11·18 miles above the Northern Outfall Sewer. Early in the morning of the 27th September, at high water, the float had reached a point just below Putney Bridge, or 18·70 miles above the Northern Outfall Sewer, and at low water in the morning of the same day it was 4·70 miles above the Northern Outfall Sewer. On the morning of the 29th September, being the period of high water spring tide, the float had reached at high water, Hammersmith Bridge, a point in the river 20·80 miles above the Northern Outfall Sewer, and on the succeeding low water was found at a point 6·30 miles above the Northern Outfall Sewer. At high water on the morning of the 1st October, the float was at Putney Bridge, 18·71 miles above the Northern Outfall Sewer, and at low water about noon on the same day it was 4·15 miles above the Northern Outfall Sewer. On the morning of 4th October the float was at Vauxhall, being 14·28 miles above the Northern Outfall Sewer, and on the succeeding low water in the afternoon of the same day, it was 2·95 miles above the Northern Outfall Sewer. In the afternoon of the 6th October, being the period of neap tide, at high water, the flood was at Vauxhall, being 13·53 miles above the Northern Outfall Sewer, and on the succeeding tide of the morning of the 7th October, it was 4·35 miles above the Northern Outfall Sewer. At high water about mid-day on the 8th October the float was at the Victoria Railway Bridge, 15·45 miles above the Northern Outfall Sewer, and at low water in the afternoon of the same day it reached a point 3·70 miles above the Northern Outfall Sewer. At high water in the morning of the 12th of October, the float was at Putney, 18·87 miles above the Northern Outfall Sewer, and at low water in the morning of the same day it was 6·08 miles above the Northern Outfall Sewer. On the morning of the 13th October at high water, the float was 19·80 miles above the Northern Outfall Sewer, and at low water in the morning of the same day was 6·03 miles above the Northern Outfall Sewer. On the morning of the 14th October, being the period of high water spring tide, at high water the float was 20·15 miles above the Northern Outfall Sewer, and at low water in the morning of the same day, it was 7·10 above the Northern Outfall Sewer. At high water on the morning tide of the 15th October, the float had ascended the river to a point 19·30 miles above the Northern Outfall Sewer, and on the succeeding low water, in the morning of the same day, it was in Blackwall Reach at a point 5·92 miles above the Northern Outfall Sewer. At high water in the morning of the 16th October the float was at a point in the river between Chelsea and Battersea Bridge, 16·85 miles above the Northern Outfall Sewer, and on the succeeding low water, in the morning of the same day, it was in Bugsby's Reach, 4·75 miles above the Northern Outfall Sewer. At high water, on the morning of the 17th October, the float was 17·02 miles above the Northern Outfall Sewer, and at low water on the descending tide in the same morning, it was in Bugsby's Reach, 4·39 miles above the Northern Outfall Sewer. After this the float began to descend the river, and at low water at mid-day on the 18th October, it had reached a point 1·0 mile above the Northern Outfall Sewer, and on the succeeding high water in the afternoon of the 18th October it was at Waterloo Bridge, 12·75 miles above the Northern Outfall Sewer. On the following ebb tide a fog came on and this float was lost sight of. It was, however, started again on the flood tide in the afternoon of the 19th October, being placed in the same position with reference to No. 7 float, having worked continuously throughout this period. At high water on the afternoon of the 19th October, the float was in the Upper Pool, 10·89 miles above the Northern Outfall Sewer, and on the succeeding low water, in the early morning of the 20th October, it had reached a point 0·65 of a mile below the Northern Outfall Sewer. At high water on the morning of the 21st October, being the period of neap tide, the float was 7·90 miles above the Northern Outfall Sewer, and on the succeeding low water, on the afternoon of the 21st October, was 3·25 miles below the Northern Outfall Sewer. On the morning of the 22nd October, at high water, the float was nearly opposite Greenwich, at a point 6·62 miles above the Northern Outfall Sewer, and at low water, in the afternoon of the 22nd October, it reached a point 2·97 miles below the Northern Outfall Sewer. On the succeeding high water on the night of the 22nd October, the float was in Limehouse Reach, 8·37 miles above the Northern Outfall Sewer, and so the float ascended and descended the river until low water in the morning of the 24th October, when it reached a point 6·53 miles below the Northern Outfall Sewer. On the succeeding high water, on the morning of the 24th October, the float had reached a point near the Millwall Dock entrance, being 8·00 miles above the Northern Outfall Sewer. Shortly after this a gale came on and the observations with this float were discontinued.

It will be observed that in the 31 days this float was in the river, counting from low water to low water, it progressed down the river 6·53 miles. In the first 26 days, in which there was no break in the observations with this float, it had advanced at low water 1·00 mile up the river, or if two complete lunations are taken, ending in the afternoon on the 21st October, at low water, the float had descended 3·25 miles down the river.

*No. 7 Float.*

No. 7 float was put into the river at half flood, opposite the Northern Outfall Sewer, at 6 A.M. on the 6th October, being the period of neap tide. On the completion of its flow up the river, at high water, it was in Bugsby's Reach, 4·40 miles above the Northern Outfall Sewer, and on the succeeding low water, on the 6th October, it descended to a point in Erith Rands, 5·10 miles below the Northern Outfall Sewer. On the afternoon tide of the 7th October, the float had reached a point at high water, near Millwall Dock entrance, 8·00 miles above the Northern Outfall Sewer, and at low water on the succeeding morning tide of the 8th October, it had descended to a point near Rainham Creek, 3·55 miles below the Northern Outfall Sewer. On the early morning tide of the 10th October, at high water, the float was near the Thames Tunnel, being 10·00 miles above the Northern Outfall Sewer, and at low water on the succeeding tide of the 10th October it had descended to a point in Erith Reach, 3·60 miles below the Northern Outfall Sewer. On the early morning tide of the 12th October the float had reached Blackfriars, or was at a point 12·20 miles above the Northern Outfall Sewer, and on the succeeding low water on the morning of the 12th October it was in Halfway Reach, 1·50 miles below the Northern Outfall Sewer. On the early morning tide of the 13th October, at high water, the float was 14·70 miles above the Northern Outfall Sewer, being opposite Pimlico Pier, and on the succeeding low water was in Barking Reach, 0·10 of a mile above the Northern Outfall Sewer. At high water, in the morning of the 14th October, being the period of high water spring tide, the float was at Battersea Park Pier, 15·40 miles above the Northern Outfall Sewer. On the succeeding low water, on the morning of the 14th October, it was in Woolwich Reach, 3·00 miles above the Northern Outfall Sewer, and on the following high water, in the afternoon of the 14th October, it was at Battersea Bridge, 16·45 miles above the Northern Outfall Sewer, and on the succeeding low water it had descended to a point opposite North Woolwich Station, being about 2·00 miles above the Northern Outfall Sewer. At high water on the afternoon tide of the 16th October, the float was at Chelsea Bridge, being 16·40 miles above the Northern Outfall Sewer. On the succeeding low water, on the night of the 16th October, the float was in Woolwich Reach, 3·15 miles above the Northern Outfall Sewer. On the 18th October, on the afternoon tide, the float had reached a point about Charing Cross, 12·97 miles above the Northern Outfall Sewer. In the afternoon of the 18th October, the float was lost sight

App. R.

of in Blackwall Reach for about four hours, but was found on the flood tide at North Woolwich Station. It was clear, however, from the position in which the float was found that it had continued to travel its proper course, and on the succeeding high water, in the early morning of the 19th October, it had reached a point in Barking Reach 1·40 mile below the Northern Outfall Sewer, and so it continued to travel backwards and forwards until the morning tide of the 21st October, being the period of neap tide, when at high water it was near the Millwall Dock entrance, or 8·00 miles above the Northern Outfall Sewer, and on the succeeding low water in the afternoon of the 21st October, it had descended to a point near the mouth of the Beam River, being 2·80 miles below the Northern Outfall Sewer. On the morning of the 22nd October, at high water, the float was in Greenwich Reach, 7·00 miles above the Northern Outfall Sewer, and on the succeeding low water, in the afternoon of the same day, it was in Halfway Reach, 3·32 miles below the Northern Outfall Sewer, and so the float continued to ascend and descend the river, until at low water, on the morning of the 24th October, it was below Erith, at a point about 5·25 miles below the Northern Outfall Sewer, and on the succeeding high water of the tide on the morning of the 24th October, it reached a point in Greenwich Reach, 6·63 miles above the Northern Outfall Sewer, when a gale came on to blow, and the experiment was discontinued.

It will be seen, counting from high water to high water, that in the eighteen days this float was in the river, it made a progress of 2·23 miles up the river. If we take one period of similar lunation, ending on the 20th October, it will be seen that the upward progress of the float was 3·50 miles.

*No.* 8 *Experimental Float.*

No. 8 experimental float was put into the river at Teddington, at high water, at 3h. 40m. in the afternoon of the 27th October 1882. On the ebb tide of that afternoon it floated down to Vauxhall, being a distance of 15·49 miles. On the return tide, early in the morning of the 28th October, at high water it had reascended the river a distance of 6·75 miles above the point which it had reached at the previous low water. On the succeeding ebb tide of the 28th October, it floated down the river a distance of 15·16 miles, and had reached a point in the upper part of Blackwall Reach. On the following flood tide, in the afternoon of the 28th October, it was carried up the river 11·02 miles, to a point above Chelsea Bridge, and on the succeeding ebb tide, on the afternoon of that day, it descended the river 15·52 miles, to a point in the lower part of Woolwich Reach, being 1·74 miles above the Northern Outfall Sewer. On the succeeding flood tide, at high water, in the early morning of the 29th October, the float had passed up the river 11·03 miles, being at Waterloo Bridge, and at low water on the succeeding ebb tide of the same day, it passed down the river 14·22 miles, or to the "Leather Bottle," at Crossness, 1·45 miles below the Northern Outfall Sewer. On the high water of the succeeding flood tide it passed up the river 10·61 miles, being opposite the Regent's Canal Dock, 9·16 miles above the Northern Outfall Sewer. The experiments at this point were discontinued on account of the rough weather.

In the two days that this float had been floating down the river it will be observed that it descended a distance of 20·98 miles.

*No.* 9 *Experiment, or Simultaneous Observations.*

On the 3rd November 1882, three floats were put into the river at high water at the following places, viz., one at Vauxhall Bridge, a second in the upper part of Limehouse Reach, near the West India Dock west entrance, and a third 150 yards above the Metropolitan Southern Outfall Sewer at Crossness.

The first of these floats descended upon the ebb tide 13·70 miles, or to a point in Galleon's Reach; the second 11·78 miles, or to near the mouth of the Beam River in Halfway Reach; and the third 11·14 miles, or to a point near the lower part of Northfleet Hope. On the succeeding flood tide the first float reascended the river 8·51 miles, the second 9·48 miles, and the third 8·11 miles

On the 6th November four floats were put into the river at high water at the following points, viz., the first at Vauxhall Bridge; the second in the upper part of Limehouse Reach, near the West India Dock west entrance; the third at a point 150 yards above the Metropolitan Southern Outfall at Crossness; and the fourth in the lower part of Gravesend Reach, just above Shorne Mead Battery. On the ebb tide the first float descended a distance of 12·62 miles, or to a point near Woolwich Ferry; the second 11·72 miles, or to a point near the mouth of the Beam River; the third 10·92 miles or to a point near the lower part of Northfleet Hope; and the fourth 13·21 miles, or to about three-quarters of a mile below London Stone. On the return flood tide, the first float reascended the river 9·42 miles, or to a point near the Tower Subway; the second 11·69 miles, or to a point near the West India Dock west entrance; the third 9·70 miles, or to a point in the lower part of Halfway Reach; and the fourth 8·41 miles, or to a point in the upper part of Sea Reach.

On the 7th November, the four floats were again put into the river at high water, at the same points as on the previous day. The first float descended 12·65 miles, or to a point in the lower part of Woolwich Reach; the second 11·72 miles, or to a point in Halfway Reach; the third 11·72 miles, or to a point opposite Rosherville Pier; and the fourth 12·32 miles, or to a point near London Stone. On the return flood tide the first float reascended the river 9·48 miles, or to a point near the Tower Subway; the second float 11·07 miles, or to a point in Limehouse Reach; and the third float 10·32 miles, or to a point opposite Rainham Creek. The fourth float on this occasion did not reascend the river on account of the rough weather.

The last two days' observations show that the range of the tide with No. 1 float on the flood tide, in the upper part of the river, was 9·45 miles; No. 2 float, somewhat lower in the river than No. 1 float, 11·38 miles; No. 3 float, lower still in the river, 10·01 miles; and No. 4 float, in the lower part of the river, 8·41 miles;* while on the ebb tide No. 1 float in the upper part of the river, had an average range of 12·63 miles; No. 2 float, at a lower point in the river, 11·72 miles; No. 3 float, still lower in the river, 11·32 miles; and No. 4 float, in the lower part of the river, 12·76 miles.

*No.* 10 *Experiment.*

In this experiment two sets of floats were used, viz., deep floats, such as were used in the observations Nos. 1 to 7, and surface floats, the object being to ascertain the effect of mixture by the ebb and flow of the tides in the river, and the relative velocity of these floats in various parts of the river.

The first experiment consisted in putting into the river at low water, at London Stone, on the 29th October, at 8·25 A.M., a float of the same kind as used in the observations Nos. 1 to 7. So soon as the float had been put into the river, samples of water in duplicate were drawn at one foot below the surface, and also at half the depth of the river, in order to ascertain the amount of chlorine in the water. When the float had passed on the flood tide as far as Middle Blythe Buoy, No. 2 samples of water were taken alongside the float in a similar way to those taken at the starting; and when the float had reached Cliffe Creek, a distance of 11·00 miles from the point of starting, No. 3 samples of water were taken; and when the float had come to rest at high water, after having gone up the river a distance of 13·40 miles, or to a point in Gravesend Reach, No. 4 samples of water were taken. On the morning tide of the 30th October, the same float was put into the river at low water in Gravesend Reach, at the same point that it had reached at high water on the morning of the preceding day. No. 5 samples of water were taken alongside the float after it was placed in the river, both below the surface and at half the depth of the river, for the purpose of chlorine tests. When the float had passed up the river as far as Gray's Causeway, No. 6 samples of water were drawn; and as it proceeded up to Cold Harbour, No. 7 samples were drawn, and at the end of its course at high water, near the Metropolitan Southern Outfall, having travelled up the river 14·25 miles, No. 8 samples were drawn. On the following day, the 31st October, at low water, the float was again put into the river, near the Metropolitan Southern Outfall Sewer, at the same point it had reached at high water on the preceding day, and before starting up the river No. 9 samples of water were drawn; and as the float passed up the river, when it reached a point near North Woolwich, No. 10 samples of water were drawn. As the float travelled still farther up the river, and off the Ship Hotel at Greenwich,

* This was a single observation

No. 11 samples of water were drawn; and at high water, when opposite Limekiln Dock, No. 12 samples of water were drawn, the float having travelled a distance of 11·25 miles on its flow up the river. On the following day, the 1st November, the float was again put into the river at low water, at the same spot as that at which it had arrived on the previous day tide, and No. 13 samples of water were drawn. After the float had reached London Bridge, No. 14 samples of water were taken alongside of it, and at high water, when it had arrived at Vauxhall Bridge, having travelled up the river 5·20 miles, No. 15 samples of water were drawn. On the following day, the 2nd November, a float consisting of a copper ball with bucket suspended by a chain was used, the bottom of the bucket being immersed 5 feet from the surface. The float was put in at low water at the same spot the float had reached at high water on the previous day, and No. 16 samples of water were drawn alongside of it, and at high water the float arrived at Wandsworth Bridge, having travelled a distance of 3·53 miles up the river, when No. 18 samples of water were drawn. On the following day, the 3rd November, the float was again put into the river at low water at Wandsworth Bridge, being the same place it reached on the preceding day tide at high water, and No. 19 samples of water were taken alongside of it. At high water it had passed up to the mouth of the Beverley Brook, a distance of 1·45 mile, when No. 20 samples of water were taken. At low water on the following day, the float was again put into the river opposite Beverley Brook, being the same point as it had reached on the preceding day at high water, when No. 21 samples of water were drawn. The current of land water down the river being so strong, this float only made a swim of 300 yards during the flow of the tide, and when taken out No. 22 samples of water were taken.

At high water on the 4th November, a surface float was put into the river at Teddington Weir at 9.37 A.M., when No. 23 samples of water were taken alongside of it. When the float had flowed down to the top of Chiswick Eyot, No. 24 samples of water were drawn, and at low water the same day the float had arrived at a point opposite the City of London Schools, having travelled a distance of 17·80 miles, when No. 25 samples of water were taken. On the morning tide of the 5th November, at high water, the float was again put into the river opposite the City of London Schools, when No. 26 samples of water were drawn. On the float arriving at Greenwich Pier, No. 27 samples of water were drawn, and as the float swam down the river, opposite the Albert Dock entrance, No. 28 samples of water were drawn, and at low water the float had arrived at the "Leather Bottle" at the top of Halfway Reach, having travelled a distance of 14·00 miles down the river, when No. 29 samples of water were drawn. On the morning tide of the 6th November, the float was again put into the river at high water, at the "Leather Bottle," being the same point as it had reached on the previous day at low water, when No. 30 samples of water were taken alongside of it. As the float passed down the river, when near the middle of Erith Rands, No. 31 samples of water were drawn, and on arriving at the middle of St. Clement's Reach No. 32 samples of water were taken. At low water the float had reached a point opposite the mouth of the Medway Canal, having travelled a distance of 13·67 miles down the river, when No. 33 samples of water were taken. On the morning tide of the 7th November the float was again put into the river opposite the Medway Canal, being the point at which it had arrived on the preceding day at low water, when No. 34 samples of water were drawn, and as the float proceeded down the river in the Lower Hope, No. 35 samples of water were drawn, and at Canvey Island Beacon, No. 36 samples of water were drawn. At low water the float had arrived at London Stone, having travelled down the river a distance of 14·50 miles, when No. 37 samples of water were drawn.

It will be seen that, when working up the river the float only ascended from London Stone in the seven-day tides, a distance of 50 miles, and came back from Teddington, a distance of 60 miles, on four tides.

On the 30th and 31st October, and 1st, 2nd, and 3rd November, while the floats were working from Gravesend Reach up the river, a surface float was tested alongside a deep float, and when working down the river, from the 4th to the 7th November, a surface float was again tested alongside a deep float, in order to ascertain the relative rates of velocity, with the following results:—

| Date. | Deep Float ran up River. | Surface Float ran up River. |
|---|---|---|
| | Miles. | Miles. |
| October 30th | 14·25 | 13·01 |
| ,, 31st | 11·08 | 11·25 |
| November 1st | 5·14 | 5·20 |
| ,, 2nd | 3·53 | 3·48 |
| ,, 3rd | 1·45 | 1·44 |

The average of the speed of the deep floats up the river was 7·09 miles, while the average of the surface floats was 6·87 miles per tide. When flowing down the river from a point opposite the City of London Schools, the results were:—

| Date. | Deep Float ran Down River. | Surface Float ran Down River. |
|---|---|---|
| | Miles. | Miles. |
| November 5th | 13·88 | 14·00 |
| ,, 6th | 12·47 | 13·67 |
| ,, 7th | 13·90 | 14·50 |

On an average of these experiments, the deep floats passed down the river 13·41 miles, while the surface floats passed down in the same time 14·05 miles per tide, so that it will be seen on ascending the river, on an average, the surface floats moved with less velocity than the deep floats; but on descending the river, the surface floats moved with the greatest velocity.

*Horizontal Oscillation of the Tides in the River Thames.*

In the experiments made with the floats Nos. 1 to 7, which were immersed 12 feet in the tidal way between the 17th September and the 1st November inclusive, these floats completed 456 complete swims on the flood tide, and 450 complete swims on the ebb tides, in addition to which there was a swim of half a tide on the flood and two half-tides upon the ebb, which were not taken into account in ascertaining the average distance which was traversed by the floats, but they have an influence with reference to the position of the floats in the river during the period of observation. Taking the whole of the experiments upon flood tides, the average distance travelled by the floats upon the flood tides was found to be 12·60 miles per tide, and the average distance travelled by the floats upon all the ebb tides was found to be nearly the same, viz., 12·64 miles per tide. If, however, the distances traversed are taken at different periods, they vary. From the 17th September to the 30th September, the average distance traversed on the floods was 13·46 miles, and on the ebbs 13·29 miles per tide. Between the 1st and 16th October, the average distance travelled on the floods was 12·51, and on the ebbs 12·40 miles per tide. From the 17th October to the 1st November the average distance travelled on the floods was 11·95 miles, and on the ebbs 12·41 miles per tide. Taking the observations made with the recording machines upon the vertical range of the tides, it is found that there is a difference of time between ebb and flow, and the length of flood and ebb at Teddington, Deptford, Erith, Gravesend, and Southend, as shown by the following figures:—

| | Flood. | Ebb. | Whole Tide. |
|---|---|---|---|
| | H. M. | H. M. | H. M. |
| Teddington | 2 3 | 10 10 | 12 13 |
| Deptford | 5 30 | 6 55 | 12 25 |
| Erith | 5 51 | 6 34 | 12 25 |
| Gravesend | 5 57 | 6 27 | 12 24 |
| Southend | 6 3 | 6 22 | 12 25 |

In all cases the period of ebb is longer than that of flow, but the times vary in different parts of the river.

The accompanying Table, No. 1, shows the distance the floats passed over on every tide up and down the river, and the diagrams show the position of these floats in every part of the river during the period of observation.

## TABLE No. 1.

TABLE of OBSERVATIONS showing the DISTANCE FLOATS IMMERSED 12 FEET TRAVELLED on the FLOOD and EBB TIDES in the RIVER THAMES, from the 17th SEPTEMBER to the 1st NOVEMBER 1882.

| Date. | No. 1 Float. | | | | No. 2 Float. | | | | No. 3 Float. | | | | No. 4 Float. | | | | No. 5 Float. | | | | No. 6 Float. | | | | No. 7 Float. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Morning Tide. | | Afternoon Tide. | | Morning Tide. | | Afternoon Tide. | | Morning Tide. | | Afternoon Tide. | | Morning Tide. | | Afternoon Tide. | | Morning Tide. | | Afternoon Tide. | | Morning Tide. | | Afternoon Tide. | | Morning Tide. | | Afternoon Tide. | |
| | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. | Distance travelled Down River. | Distance travelled Up River. |
| Sept. 17 | — | — | 15·84 | — | — | — | 7·40 | | | | | | | | | | | | | | | | | | | | | |
| „ 18 | 13·05 | 13·07 | 11·71 | 13·70 | 12·25 | 14·15 | 14·43 | 12·25 | 13·15 | 13·90 | 12·38 | 13·58 | | | | | | | | | | | | | | | | |
| „ 19 | 11·42 | 11·05 | 11·30 | 10·14 | 13·65 | 11·63 | 13·48 | 13·03 | 12·50 | 13·50 | 11·70 | 12·65 | | | | | | | | | | | | | | | | |
| „ 20 | 9·95 | 8·60 | 9·65 | 11·65 | 9·80 | 12·10 | 8·55 | 9·80 | 10·15 | 11·55 | 11·32 | 11·32 | | | | | | | | | | | | | | | | |
| „ 21 | 8·70 | 9·65 | 10·31 | 8·76 | 10·02 | 10·47 | 2·09 | 10·02 | 9·78 | 11·03 | 10·35 | 9·05 | | | | | | | | | | | | | | | | |
| „ 22 | 1·30 | 9·23 | 8·91 | 9·78 | 9·92 | 8·52 | 10·48 | 8·97 | 9·80 | 9·77 | 10·75 | 9·48 | 6·95 | 7·32 | 11·07 | 8·65 | 4·95 | — | 10·96 | 11·23 | — | — | 10·18 | 10·18 | | | | |
| „ 23 | 0·65 | 9·91 | — | 11·40 | 10·48 | 8·58 | — | 10·95 | 10·65 | 9·70 | — | 11·38 | 9·05 | — | — | 11·19 | 11·15 | 10·96 | 11·90 | 11·95 | — | — | — | 11·75 | | | | |
| „ 24 | 1·40 | 12·00 | 12·00 | 14·40 | 10·92 | 10·15 | 11·05 | 12·75 | 11·38 | 10·42 | 12·37 | 12·02 | 11·35 | 9·20 | 10·65 | 13·10 | 11·20 | 11·95 | — | 14·10 | 11·78 | 11·18 | 12·18 | 14·38 | | | | |
| „ 25 | 1·88 | 13·53 | 13·53 | 14·13 | 12·28 | 11·78 | 12·95 | 14·72 | 12·72 | 12·88 | 13·33 | 15·75 | 13·30 | 12·30 | 14·05 | 15·32 | 13·55 | 12·70 | 12·70 | 15·05 | 12·65 | 12·85 | 13·73 | 15·03 | | | | |
| „ 26 | 2·53 | 14·47 | 15·00 | 15·38 | 13·82 | 14·72 | 14·72 | 16·13 | 13·53 | 13·65 | 14·65 | 16·60 | 13·42 | 14·15 | 14·15 | 15·77 | 13·70 | 14·65 | 15·30 | 17·00 | 13·35 | 14·95 | 14·85 | 17·10 | | | | |
| „ 27 | 4·02 | 13·57 | 17·05 | 16·80 | 14·23 | 14·77 | 16·40 | 15·05 | 13·85 | 14·23 | 15·03 | 16·40 | 15·77 | 14·85 | 18·10 | 16·40 | 14·27 | 15·42 | 16·80 | 17·95 | 14·00 | 14·15 | 15·15 | 15·15 | | | | |
| „ 28 | 7·45 | 17·50 | 16·10 | 18·18 | 14·25 | 14·48 | 16·10 | 18·00 | 14·70 | 14·25 | 14·53 | 16·36 | 13·75 | 14·45 | 15·50 | 18·90 | 16·20 | 16·20 | 15·77 | 18·12 | 14·05 | 14·45 | 14·55 | 16·10 | | | | |
| „ 29 | 15·18 | 12·46 | 15·71 | 16·35 | 13·24 | 14·55 | 15·65 | 17·25 | 15·06 | 14·78 | 15·20 | 14·15 | 16·15 | 12·55 | 16·65 | 15·95 | 16·00 | 14·95 | 75·85 | 14·48 | 14·50 | 14·00 | 15·05 | 15·00 | | | | |
| „ 30 | 15·90 | 15·87 | 15·81 | — | 15·75 | 16·10 | 17·00 | 16·02 | 14·90 | 14·08 | 15·33 | — | 14·50 | 15·30 | 12·65 | 12·75 | 14·76 | 14·98 | 15·80 | 15·85 | 14·95 | 13·95 | 14·72 | — | | | | |
| Oct. 1 | 15·33 | 15·79 | 12·75 | 13·96 | 15·10 | 13·24 | 15·50 | 15·88 | 14·20 | 11·10 | 14·52 | 14·52 | 15·75 | 16·20 | 14·95 | 12·82 | 15·15 | 14·25 | 14·10 | 13·93 | 14·56 | 14·18 | 14·62 | 14·37 | | | | |
| „ 2 | 13·24 | 12·03 | 14·05 | 14·93 | 13·28 | 11·77 | 13·33 | 13·02 | 13·40 | 13·20 | 13·40 | 14·72 | 12·72 | 13·55 | 13·45 | 11·40 | 14·23 | 14·35 | 13·40 | — | 14·70 | 14·25 | 13·10 | 14·45 | | | | |
| „ 3 | 14·59 | 12·34 | 14·28 | 13·03 | 13·27 | 9·85 | 13·65 | 12·45 | 13·55 | 12·03 | 12·30 | 12·30 | 14·80 | 13·20 | 9·92 | — | 13·30 | 11·75 | 12·00 | 12·60 | 12·85 | 11·00 | 11·88 | 12·90 | | | | |
| „ 4 | 10·23 | 10·88 | 10·40 | 11·35 | 10·28 | 8·45 | 10·55 | 11·38 | 11·63 | 11·15 | 10·73 | 11·73 | 8·25 | 9·12 | 8·80 | 10·43 | 12·95 | 11·00 | 10·88 | 12·80 | 11·33 | 10·31 | 10·30 | 11·35 | | | | |
| „ 5 | 8·91 | 9·34 | 9·82 | 12·00 | 7·80 | 6·98 | 6·95 | 9·60 | 9·35 | 9·18 | 9·98 | 10·63 | 8·05 | 8·52 | 9·05 | 9·40 | 9·50 | 9·88 | 9·98 | 10·63 | 9·10 | 8·95 | 9·15 | 10·50 | | | | |
| „ 6 | 6·75 | 8·82 | 11·34 | 10·09 | 8·51 | 9·25 | 10·15 | 10·68 | 9·05 | 8·95 | 9·52 | 9·20 | 7·00 | 8·40 | 10·85 | 8·60 | 9·05 | 8·95 | 9·52 | 9·20 | 8·85 | 8·40 | 10·18 | 9·78 | 9·50 | 4·20 | 10·60 | 11·10 |
| „ 7 | 11·82 | 10·95 | — | 11·77 | 10·20 | — | — | 9·55 | 10·87 | 9·37 | — | 11·92 | 10·15 | 9·00 | — | 11·02 | 10·87 | 9·37 | — | 11·92 | 10·90 | 9·95 | — | 12·02 | 11·10 | 10·90 | — | 12·80 |
| „ 8 | 10·76 | 10·44 | 13·16 | 12·09 | 10·15 | 11·15 | 11·85 | 11·80 | 10·99 | 11·44 | 11·99 | 12·55 | 10·04 | 8·69 | 11·72 | 11·72 | 10·90 | 11·44 | 11·99 | 12·55 | 11·02 | 11·05 | 11·75 | 12·65 | 11·55 | 10·18 | 11·13 | 12·50 |
| „ 9 | 12·31 | 12·56 | 12·86 | 13·94 | 11·25 | 11·75 | 11·00 | 11·50 | 11·40 | 11·45 | 12·55 | 13·58 | 11·72 | 11·55 | 13·55 | 13·67 | 11·40 | 11·45 | 12·55 | 13·58 | 11·45 | 11·50 | 12·85 | 13·25 | 11·55 | 11·55 | 12·00 | 14·00 |
| „ 10 | 13·64 | 13·57 | 13·62 | 13·70 | 12·05 | 12·65 | 12·80 | 14·05 | 12·48 | 12·92 | 13·22 | 13·87 | 12·57 | 13·65 | 12·35 | 13·65 | 12·48 | 12·92 | 13·22 | 12·87 | 11·90 | 13·30 | 13·41 | 13·73 | 13·60 | 13·60 | 13·60 | 14·72 |
| „ 11 | 13·65 | 13·60 | 12·32 | 12·90 | 12·45 | 12·95 | 11·58 | 11·98 | 12·57 | 12·90 | 13·28 | 13·28 | 13·32 | 13·12 | 13·10 | 13·30 | 12·57 | 12·90 | 13·23 | 13·28 | 12·85 | 13·33 | 13·39 | 13·17 | 13·32 | 13·40 | 13·42 | 14·32 |
| „ 12 | 12·95 | 11·72 | 12·90 | 13·29 | 14·29 | 12·51 | 14·87 | 14·75 | 12·75 | 13·75 | 14·15 | 14·25 | 12·55 | 11·60 | 13·05 | 13·05 | 12·75 | 13·75 | 14·15 | 14·25 | 12·79 | 13·02 | 13·72 | 14·12 | 13·70 | 14·95 | 14·85 | 16·10 |
| „ 13 | 14·24 | 13·78 | 15·28 | 15·30 | 12·90 | 14·30 | 14·00 | 13·35 | 13·90 | 13·80 | 13·90 | 14·15 | 14·65 | 13·90 | 13·50 | 14·20 | 13·90 | 13·80 | 13·90 | 14·15 | 13·77 | 13·42 | 13·45 | 14·15 | 14·00 | 14·25 | 14·38 | 15·45 |
| „ 14 | 13·55 | 13·42 | 13·02 | — | 14·90 | 14·22 | 13·74 | — | 13·15 | 12·40 | 13·47 | — | 13·95 | 14·00 | 14·00 | 14·75 | 13·15 | 12·40 | 13·47 | — | 14·05 | 12·32 | 13·70 | — | 12·45 | 13·50 | 14·55 | 14·60 |
| „ 15 | 14·22 | 14·12 | 15·42 | 13·69 | 14·20 | 14·97 | 13·01 | 14·51 | 13·35 | 13·57 | 13·25 | 11·50 | 13·80 | — | 12·75 | 13·73 | 13·35 | 13·57 | 13·25 | 11·50 | 13·38 | 13·58 | 12·71 | 11·49 | 14·28 | — | 13·26 | 13·46 |
| „ 16 | 11·63 | 13·58 | 11·17 | 15·63 | 12·77 | 12·77 | 12·78 | 14·23 | 12·82 | 13·12 | 12·77 | 12·77 | 11·25 | 13·25 | 12·05 | 15·55 | 12·82 | 13·12 | 12·77 | 12·77 | 12·10 | 12·15 | 12·56 | 11·88 | 12·74 | 13·27 | 13·25 | 13·40 |
| „ 17 | 13·18 | 16·03 | 11·72 | 12·14 | 12·00 | 12·70 | 12·25 | 12·25 | 12·90 | 12·90 | 13·45 | 11·20 | 13·08 | 14·18 | 12·46 | 12·53 | 12·90 | 12·90 | 13·45 | 11·20 | 12·03 | 12·95 | 13·02 | 11·53 | 12·35 | 12·85 | 13·75 | 11·80 |
| „ 18 | 13·42 | 11·25 | 13·13 | 12·27 | 12·72 | 10·62 | — | 11·55 | 13·19 | 11·95 | — | 11·85 | 13·52 | 12·47 | 13·45 | 12·25 | 13·40 | 11·95 | — | 11·85 | 13·40 | 11·50 | — | 11·75 | 12·52 | 12·42 | 13·49 | 12·47 |
| „ 19 | 10·49 | 12·28 | 11·28 | 11·83 | — | — | — | — | — | — | 11·58 | — | 10·97 | 12·39 | 10·18 | 11·58 | — | — | 11·58 | — | — | — | 11·54 | 9·76 | 12·50 | 11·62 | 12·04 | 12·08 |
| „ 20 | 11·40 | 8·49 | 9·18 | 9·60 | — | — | — | — | 11·15 | 9·78 | 10·25 | 10·20 | 11·57 | 9·15 | 11·15 | 9·40 | 11·15 | 9·78 | 10·25 | 10·20 | 10·75 | 9·72 | 10·26 | 10·24 | 11·25 | 10·43 | 11·02 | 11·00 |
| „ 21 | 9·07 | 8·55 | 9·76 | 10·10 | — | — | — | — | 11·20 | 10·00 | — | 10·05 | 8·98 | 9·10 | 9·71 | 9·63 | 11·20 | 10·00 | — | 10·05 | 11·15 | 9·59 | 8·92 | 10·02 | 10·80 | 10·20 | 10·05 | 10·70 |
| „ 22 | 10·04 | 8·30 | — | 10·10 | — | — | — | — | 10·11 | 9·02 | 9·14 | 11·73 | 9·53 | 8·31 | — | 9·53 | 10·11 | 9·02 | 9·14 | 11·73 | 9·59 | 8·77 | — | 11·34 | | 9·15 | 10·32 | 12·12 |
| „ 23 | 11·34 | 8·78 | 12·70 | 12·19 | — | — | — | — | 10·65 | 9·87 | 13·77 | 12·88 | 10·30 | 7·70 | 13·55 | 12·70 | 10·65 | 9·87 | 13·77 | 12·88 | 11·13 | 9·93 | 12·17 | 11·30 | 12·00 | 10·95 | 13·27 | 13·52 |
| „ 24 | 10·13 | 12·55 | — | — | — | — | — | — | 12·88 | 12·80 | — | — | 9·50 | 12·20 | — | — | 12·88 | 12·80 | — | — | 12·83 | 14·53 | — | — | 13·25 | 11·88 | — | — |
| „ 25 | — | — | — | 16·70 | — | — | — | — | — | — | — | — | — | — | — | 16·05 | — | — | — | — | — | — | — | — | — | — | — | — |
| „ 26 | — | — | 14·08 | 17·30 | — | — | — | — | — | — | 12·79 | 16·67 | — | — | 13·57 | 16·72 | — | — | 12·79 | 16·67 | — | — | — | — | — | — | — | — |
| „ 27 | 15·80 | 15·85 | 15·85 | 17·81 | — | — | — | — | 16·66 | 15·26 | 13·53 | 14·85 | 14·32 | 16·42 | 15·90 | 16·81 | 16·66 | 15·26 | 13·53 | 14·85 | — | — | — | — | — | — | — | — |
| „ 28 | 13·82 | 13·76 | — | — | — | — | — | — | 14·85 | 14·50 | 14·53 | — | 13·12 | 12·24 | — | — | 14·85 | 14·50 | 14·53 | — | — | — | — | — | — | — | — | — |
| „ 29 | — | — | 17·30 | — | — | — | — | — | 14·71 | 11·23 | 11·73 | 12·89 | — | — | — | — | 14·71 | 11·23 | 11·73 | 12·89 | — | — | — | — | — | — | — | — |
| „ 30 | 15·40 | 12·65 | 15·00 | 13·30 | — | — | — | — | 13·88 | 11·73 | 16·10 | 13·45 | — | — | — | — | 13·88 | 11·73 | 16·10 | 13·45 | — | — | — | — | — | — | — | — |
| „ 31 | 15·47 | 14·60 | 15·10 | 14·87 | — | — | — | — | 16·27 | 16·02 | 15·15 | 13·90 | — | — | — | — | 16·27 | 16·02 | 15·15 | 13·90 | — | — | — | — | — | — | — | — |
| Nov. 1 | 16·95 | 13·90 | — | — | — | — | — | — | 13·50 | 12·80 | — | 11·05 | — | — | — | — | 13·50 | 12·80 | — | 11·05 | — | — | — | — | — | — | — | — |
| Averages | 12·50 | 12·26 | 13·09 | 13·24 | 12·22 | 12·06 | 12·78 | 13·02 | 12·61 | 12·27 | 12·84 | 12·86 | 11·99 | 11·89 | 12·77 | 13·01 | 12·98 | 12·56 | 13·19 | 13·30 | 12·38 | 12·19 | 12·64 | 12·69 | 12·11 | 12·05 | 12·65 | 13·13 |
| Average of No. 5 float from 22nd September to morning tide of 5th October | | | | | | | | | | | | | | | | | 13·46 | 13·31 | 13·79 | 14·76 | | | | | | | | |

NOTE.—The figures in No. 5 float observations from the afternoon of the 5th October to the end of the experiment are the same as for No. 3 float. The figures in italics, being only parts of the full tidal flow, are not added in the averages.

*Vertical Range and Mean Level of Tide.*

For many years past the vertical range of the tides, except in the mouth of the river, has been proportionately increasing. This is specially shown in recent years by the increasing number of high tides in the Thames, and also by increased range of tide. From Mr. Redman's Paper in the Minutes of Proceedings of the Institution of Civil Engineers, vol. xlix., the range of tide in the Pool was shown to have increased, between 1800 and 1874, 4 feet, as will be seen from the following figures:—

1800 = 18·0 feet.
1843 = 19·5 ,,
1864 = 20·3 ,,
1866 = 20·6 ,,
1874 = 22·0 ,,

The highest tide on record in the Thames occurred on the 18th January 1881, on which occasion the tide rose to 4 feet 10 inches above Trinity High Water (17·33 above Ordnance Datum) at London Bridge, and 3 feet 9 inches above Trinity High Water (16·25 above Ordnance Datum) at Gravesend. There was a table of high tides in the Thames published in the report of the Government Referees in 1857, which shows that the highest tide on record up to that time occurred on the 12th November 1852, when the tide rose to a level of 3 feet 9 inches above Trinity high-water mark (16·25 above Ordnance Datum) at the Wapping entrance to the London Docks. Since 1873 the tides have risen to a higher point than before, and culminated in the high tide of January 1881. It also appears that in the highest parts of the tidal portion of the river, as at Teddington, the range of high water has increased, for in a phamphlet by Dr. Sayer, published in 1858, the range of forty-five spring tides at Teddington is given as 2 feet 5 inches, and neap tides 1 foot 0½ inch. He also gave the mean rise of the same number of spring tides as 10 feet 1 inch at Strand-on-the-Green, and at Blackfriars Pier 17 feet 6½ inches, and the rise of an equal number of neap tides as 8 feet 8 inches at Strand-on-the-Green, and 15 feet 4¾ inches at Blackfriars Pier.

The observations taken in September, October, and November 1882, show the average vertical range of the tide at the following places to be—

| | Feet. |
|---|---|
| Southend Pier - - | 14·36 |
| Gravesend Pier - - | 16·57 |
| Erith Pier - - - | 17·55 |
| Deptford Cattle Market - | 18·29 |
| Teddington Lock - - | 3·70 |

In the same period, the range of a single tide on the 28th September 1882, was—

| | Feet. |
|---|---|
| Southend Pier - - | 19·2 |
| Gravesend Pier - - | 21·4 |
| Erith Pier - - | 22·7 |
| Deptford Cattle Market - | 23·8 |
| Teddington Lock - - | 9·1 |

The greatest range from highest high water to lowest low water on different tides was—

| | Feet. |
|---|---|
| Southend Pier - - | 19·6 |
| Gravesend Pier - - | 22·3 |
| Erith Pier - - - | 27·5 |
| Deptford Cattle Market - | 28·1 |
| Teddington Lock - - | 12·2 |

The mean level of the tide in the river at the London Docks is stated in Mr. Redman's Paper, before referred to, so be 2 feet 6 inches above Ordnance Datum. In the observations made on the river for the Commissioners of Sewers, in one month, in June and July 1849, it was stated to be:—

| | Feet. | |
|---|---|---|
| Deptford - | 2·02 | above Ordnance Datum. |
| London Bridge - | 2·44 | ,, ,, ,, |
| Battersea - | 2·50 | ,, ,, ,, |

The observations made on the river in the months of September, October, and November, 1882, show that the mean tides were as under:—

| | Feet. | |
|---|---|---|
| Southend Pier - | 1·89 | above Ordnance Datum. |
| Gravesend Pier - | 1·94 | ,, ,, ,, |
| Erith Pier - - | 1·96 | ,, ,, ,, |
| Deptford Cattle Market | 1·98 | ,, ,, ,, |
| Teddington Lock - | 11·00 | ,, ,, ,, |

In the case of Teddington, the level has been arrived at from observing the levels in a number of tides when the volume of water has been about that of the mean flow of the river, for at this high point in the river the volume of upland water coming down very materially affects the level of the tide.

The observations on the range of the tide show that low water at Southend, on an average of all the tides between September and November, 1882, is 1·87 feet higher than Deptford. On the 27th September, 1882, low water at Deptford was 2·5 feet lower than at Southend. Low water at Gravesend, on the average, was 1·06 feet lower than at Southend, and low water at Erith 1·52 feet lower than at Southend. High water at Southend, on an average of all the tides from September to November, 1882, was 2·06 feet lower than high water at Deptford. On the 28th September, 1882, high water at Deptford was 2·60 feet above that at Southend. On the average of all the experiments, high water at Gravesend was 1·16 feet above that at Southend, and at Erith 1·66 feet above that at Southend.

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Previous Observations which have been made in the River Thames with a view to ascertain the Range of the Tides in regard to the question of the Sewage Outfalls for the Metropolis.

It appears that some of the earliest investigations, of which there is any record, of the horizontal range and velocity were made for the Corporation of London, who were then the Conservators of the Thames, by Sir John Rennie, C.E., and W. C. Mylne, Esq., C.E. The observations were made in 1832 with reference to the velocity of flow between the bridges. In these experiments floats of 7 feet, 4 feet, and 2 feet in length were used, and from the results of the experiments, it is shown that the greatest progress was made on the half flood and half ebb, and the least nearest low and high water. In these experiments the deeper float sometimes moved with a greater velocity than the shallower float, and, *vice versâ*, sometimes the shallowest float moving with the greatest velocity.

In 1849 the Commissioners of Sewers for the Metropolis instituted a series of tidal experiments. At this period it does not appear that any observations were made upon the horizontal movement of the tides through the river, but careful observations were made for a month, from the 19th June to the 19th July, upon the vertical range, with gauges fixed at Deptford, London Bridge, and Battersea. After it had been determined by the Commissioners of Sewers to convey the sewage into Galleon's Reach, the first series of tidal observations were made under the direction of Mr. Frank Foster. These observations were carried out by Mr. John Phillips and his assistant, Mr. William Betts, junior. A diagram of these float observations was published in the Government Report upon the Main Drainage of the Metropolis in 1857. At a later period in April 1858, the engineers appointed by the Metropolitan Board of Works, viz., Messrs. Bidder, Hawksley, and Bazalgette, reported that the diagram printed by the Government Referees was in error, and they produced a diagram of these observations, from which it will be seen that in seventy-four runs up and seventy-four runs down the river, from the 20th June to 20th August, the average rate of progress up the river was 11·98 miles per tide, and the average rate of progress down the river was 12·64 per tide.* It should be remarked, however, in reference to these observations, that they are taken so as to give an undue advance down the river, for forty-one of the swims occurred on tides that were falling, while thirty-three only occurred on rising tides. If we take an equal number of tides from the neap tide between the 23rd and 24th July 1851, and count back ten tides, the float at high water is 3¼ miles below Barking Creek, and then if we count ten tides forward from the tide in question, the float is 4¼ miles below Barking Creek, having descended the river but one mile in twenty-one tides. At high water at the period of spring tides on the 15th August the float was 2¼ miles above Barking Creek. Counting back ten tides from this tide, the float was a point 4¾ miles above Barking Creek, and counting forward ten tides from the same tide, the float had advanced to a point 9 miles below Barking Creek, or in the twenty-one

* The float used in these experiments was immersed in the water about 5 feet 6 inches.

App. R.

tides it had advanced 13¾ miles down the river. Taking the sum of these forty-two tides the float descended 14¾ miles down the river, or just over one-third of a mile per tide.

Sir J. W. Bazalgette, when giving evidence against the Great London Drainage Bill in June 1853, said that as a result of Mr. Frank Foster's Tidal Observations—Question 2723—"The sewage at Greenwich "would at certain times, even though discharged at "high water, or within two hours of high water, "return up to six miles above that point, which is "near London Bridge."

In a report of the engineers to the Metropolitan Commissioners of Sewers, 5th March 1855, it is stated that some recent float experiments show that a float put in the river at the Earl Sluice, at low water, passed up the river on the flood to Battersea Old Church, a distance of 9½ miles, while another float put in at Woolwich, was carried up on the flood tide as far as Lambeth.

In June 1856, Captain Burstal was instructed by the First Commissioner of Her Majesty's Works to make some tidal observations in the River Thames, with a view to advise him as to the effect of discharging sewage at the proposed Northern Outfall Sewer at Barking, and the Southern Outfall in Plumstead Marshes, at a point opposite the proposed Barking Outfall. The result of these observations clearly showed that the sewage, if discharged at these points, would return at certain states of the tide up the river above the point of outfall, and in consequence of this report of Captain Burstal, a scheme was prepared for removing the outfalls lower down the river, or to Rainham Creek. After it had been determined by the Metropolitan authorities to shift the outfalls to this point, and they sought the sanction for the work, Sir Benjamin Hall, the First Commissioner of Public Works, referred the whole question to the Government Referees, Captain Douglas Galton, Mr. James Simpson, C.E., and Mr. T. E. Blackwell, C.E. The inhabitants of Erith and its neighbourhood, alarmed at the prospect of the sewage being turned into the river so near to them, instructed Mr. Homfray, an engineer, to make a series of tidal observations. These observations consisted first in ascertaining the range of oscillation of the tide from the points of proposed outfall at Rainham Creek, as well as the vertical range in different parts of the river. After the observations had been made near the points of the proposed outfall, further observations were made by the same engineer in Sea Reach. The observations in Erith Reach show that even at this point the sewage discharged would have found its way back into the Metropolitan District. A full report is to be found in the Appendix to the Government Referees' Report of 1857, page 353. There is also a chart showing the direction taken by the floats, as well as a diagram showing the vertical range of the tides. It may be pointed out that Messrs. Bidder, Hawksley, and Bazalgette, in their Report in 1858, mentioned that the diagram of the vertical range of the tides referred to was evidently in error, as low water in the lower part of the river was shown to be higher than in the upper part of the river. The recent observations, as well as others, show that the error was not made by the Government Referees, and that high water at, say, London Bridge, is higher than high water at Sheerness, so low water in the river at London Bridge is absolutely lower than low water at Sheerness.

In 1857 a further series of float observations in the Thames were made by Captain Burstal, on behalf of the Government Referees, which are set forth in a chart which is given in their Report. These observations were made in the lower part of the river.

A series of observations were also made in connexion with the outfall proposed by the late Mr. M'Clean, Past President of the Institution of Civil Engineers, in the German Ocean.

The foregoing are all the tidal observations that are generally known to have been made in the River Thames, in connexion with the horizontal oscillation of the tides in reference to the outfall sewers of the Metropolis.

### Gaugings of the Thames.

The accompanying Table, No. 2, gives the quantities of water, in cube feet per minute, at the various places which have been gauged, to which is added the water supply of the London Water Companies, and the calculated quantity for the area not gauged, so that the accurate quantity of water daily passing down the Thames, during the period the tidal observations were going on, can at once be seen. The area of the Thames Basin actually gauged is 4,878 square miles.

From former surveys of the River Thames Basin, it is shown that the area above Teddington Lock is 3,676 square miles, the total area of the Thames Basin being 5,162 square miles, of which the drainage area of the River Lea constitutes 500 square miles. The quantity of water flowing down the river has been gauged at Seething Wells for a number of years past by Mr. John Taylor, C.E., and most of these records have been published, many of them in the Sixth Report of the Rivers Pollution Commissioners.

It may be mentioned that the dry weather flow of the Thames may be taken at 12 cube feet per minute per square mile, and the average flow at 30 cube feet per minute per square mile, the maximum flow in periods of excessive flood rising to 360 cube feet per minute per square mile.

The Table of Gaugings shows that during the period the tidal observations were going on, except for a few days at the commencement, there was more than an average quantity of water coming down the river.

About the 11th October a wet period commenced, and the result is shown by the large increase in the volume of the water in the river on the 14th October and subsequently, which culminated in the excessively large quantity of upland water passing down the river on the 30th October, after which it greatly diminished, but the river still continued in flood until the end of the tidal experiments.

TABLE No. 2.

| | 1882. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sept. 7. | Sept. 8. | Sept. 9. | Sept. 10. | Sept. 11. | Sept. 12. | Sept. 13. | Sept. 14. | Sept. 15. | Sept. 16. | Sept. 17. | Sept. 18. | Sept. 19. | Sept. 20. |
| | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. |
| River Thames at Teddington | 109,194 | 99,751 | 93,577 | 91,963 | 85,434 | 84,972 | 85,445 | 83,327 | 74,279 | 80,813 | 75,361 | 77,757 | 78,960 | 80,790 |
| Stream entering at Strawberry Hill | 12 | 13 | 12 | 13 | 12 | 13 | 12 | 12 | 12 | 12 | 12 | 12 | 13 | 20 |
| Stream passing through Twickenham | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| River Crane at Isleworth | 1,448 | 1,448 | 1,448 | 1,448 | 1,448 | 1,863 | 1,866 | 1,977 | 1,646 | 1,335 | 1,202 | 1,070 | 1,795 | 1,798 |
| River Brent and Grand Junction Canal | 339 | 232 | 342 | 20 | 240 | 335 | 236 | 440 | 208 | 299 | 62 | 204 | 200 | 474 |
| Stream entering at Chiswick | 17 | 17 | 17 | 17 | 17 | 17 | 17 | 67 | 52 | 27 | 1 | 1 | Nil | 20 |
| Beverley Brook | 41 | 22 | 21 | 26 | 19 | 27 | 27 | 29 | 44 | 32 | 25 | 21 | 22 | 200 |
| River Wandle | 1,900 | 1,745 | 1,576 | 1,519 | 1,578 | 1,800 | 2,059 | 1,603 | 1,735 | 1,782 | 1,782 | 1,856 | 1,750 | 1,893 |
| Regent's Canal and Limehouse Cut | 189 | 157 | 191 | 18 | 203 | 241 | 203 | 231 | 285 | 110 | 6 | 270 | 239 | 131 |
| River Ravensborne | 813 | 933 | 550 | 104 | 977 | 725 | 905 | 1,161 | 1,069 | 740 | 387 | 1,260 | 1,037 | 1,571 |
| River Lea | 2,600 | 1,277 | 1,633 | 824 | 775 | 1,867 | 1,332 | 1,468 | 1,945 | 876 | 731 | 1,590 | 1,798 | 2,485 |
| Estimated quantity from area not gauged, above Northern Outfall | 2,502 | 2,154 | 2,294 | 2,085 | 2,259 | 2,433 | 2,349 | 2,502 | 2,537 | 2,140 | 2,168 | 2,419 | 2,329 | 2,669 |
| Total above Northern Outfall | 119,059 | 107,753 | 101,665 | 98,041 | 92,966 | 94,297 | 94,455 | 92,821 | 83,816 | 88,170 | 81,741 | 86,464 | 88,147 | 92,055 |
| River Roding and Branches | 245 | 298 | 192 | 266 | 175 | 227 | 307 | 346 | 316 | 298 | 271 | 421 | 297 | 319 |
| Mayes Brook and Tributaries | 31 | 45 | 40 | 15 | 16 | 12 | 16 | 18 | 35 | 24 | 19 | 12 | 15 | 19 |
| Stream entering at Horse Shoe Corner | 40 | 43 | 40 | 32 | 43 | 47 | 40 | 40 | 41 | 43 | 43 | 43 | 43 | 47 |
| River Beam, and Stream between Rivers Beam and Ingreborne | 154 | 87 | 100 | 89 | 74 | 157 | 131 | 68 | 238 | 237 | 130 | 130 | 197 | 302 |
| River Ingreborne | 251 | 155 | 141 | 147 | 146 | 225 | 210 | 167 | 156 | 145 | 147 | 147 | 162 | 282 |
| Stream entering at Erith Reach and Streams at Wennington | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 11 | 3 | 2 | 3 | 3 | 5 | 3 |
| Mar Dyke | 69 | 75 | 72 | 72 | 72 | 69 | 98 | 98 | 111 | 136 | 123 | 123 | 108 | 158 |
| River Cray and Tributary | 3,002 | 2,364 | 2,143 | 1,638 | 2,205 | 1,959 | 2,396 | 2,626 | 1,899 | 1,610 | 1,869 | 1,959 | 1,444 | 2,143 |
| River Darent | 2,850 | 1,180 | 2,850 | 3,214 | 2,970 | 2,970 | 1,851 | 2,850 | 3,464 | 2,168 | 3,338 | 3,214 | 2,388 | 2,616 |
| Grays Chalk Quarries | 46 | 46 | 46 | 46 | 46 | 30 | 40 | 37 | 49 | 56 | 30 | 62 | 39 | 56 |
| Streams at Northfleet, Chadwell St. Mary, and Tilbury | 276 | 267 | 266 | 265 | 273 | 265 | 268 | 276 | 302 | 279 | 279 | 274 | 292 | 290 |
| Streams at Gravesend Reach, Higham, Mucking Creek, and Higham Creek | 58 | 58 | 62 | 58 | 62 | 58 | 57 | 55 | 65 | 70 | 70 | 63 | 60 | 53 |
| Streams at Stanford-le-Hope, and North of Stanford-le-Hope | 5 | 6 | 6 | 6 | 6 | 6 | 11 | 11 | 8 | 8 | 8 | 8 | 8 | 8 |
| Streams at Fobbing and North of Fobbing | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Vange Wharf and Stream | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Stream at Pitsea Creek | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Streams at Cooling | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Wall End, Barking | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 36 | 53 | 50 | 50 | 44 | 47 | 76 |
| Volume of Water Supply | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 |
| Estimated quantity from area not guaged, below Northern Outfall | 2,610 | 2,242 | 2,393 | 2,175 | 2,356 | 2,538 | 2,450 | 2,610 | 2,646 | 2,233 | 2,262 | 2,523 | 2,428 | 2,784 |
| | 144,824 | 130,753 | 126,143 | 122,191 | 117,537 | 118,987 | 118,459 | 118,160 | 109,292 | 111,619 | 106,473 | 111,580 | 111,770 | 117,301 |

TABLE No. 2—*continued.*

| | 1882. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sept. 21. | Sept. 22. | Sept. 23. | Sept. 24. | Sept. 25. | Sept. 26. | Sept. 27. | Sept. 28. | Sept. 29. | Sept. 30. | Oct. 1. | Oct. 2. | Oct. 3. | Oct. 4. |
| | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. |
| River Thames at Teddington | 116,185 | 122,461 | 147,039 | 144,021 | 157,666 | 103,425 | 98,778 | 85,287 | 115,860 | 120,386 | 139,888 | 153,582 | 117,899 | 131,006 |
| Stream entering at Strawberry Hill | 15 | 12 | 30 | 12 | 12 | 12 | 12 | 12 | 50 | 17 | 15 | 12 | 12 | 12 |
| Stream passing through Twickenham | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| River Crane at Isleworth | 1,818 | 1,684 | 1,849 | 1,628 | 1,408 | 1,728 | 1,663 | 1,730 | 2,024 | 1,892 | 1,691 | 1,490 | 1,863 | 1,863 |
| River Brent and Grand Junction Canal | 440 | 479 | 228 | 51 | 311 | 232 | 440 | 327 | 446 | 1,054 | 389 | 440 | 295 | 240 |
| Stream entering at Chiswick | 8 | 2 | Nil | Nil | Nil | Nil | 2 | 2 | 48 | 8 | 2 | Nil | Nil | Nil |
| Beverley Brook | 59 | 32 | 29 | 25 | 25 | 21 | 29 | 22 | 417 | 110 | 26 | 21 | 29 | 48 |
| River Wandle | 1,714 | 1,695 | 1,745 | 1,729 | 1,716 | 1,663 | 1,820 | 1,753 | 4,556 | 4,172 | 2,717 | 2,576 | 3,230 | 2,512 |
| Regent's Canal and Limehouse Cut | 237 | 102 | 194 | 78 | 216 | 228 | 143 | 291 | 127 | 237 | Nil | 143 | 133 | 199 |
| River Ravensborne | 977 | 579 | 510 | 122 | 657 | 1,069 | 1,161 | 727 | 4,180 | 715 | 509 | 657 | 1,004 | 509 |
| River Lea | 4,213 | 4,081 | 2,541 | 1,840 | 764 | 1,568 | 1,998 | 2,086 | 3,591 | 2,717 | 4,627 | 3,600 | 3,098 | 2,347 |
| Estimated quantity from area not gauged, above Northern Outfall | 2,826 | 2,558 | 2,613 | 2,307 | 2,224 | 2,280 | 2,572 | 2,460 | 4,031 | 3,002 | 2,947 | 2,641 | 2,752 | 2,433 |
| Total above Northern Outfall | 128,496 | 133,689 | 156,782 | 151,817 | 165,003 | 112,230 | 108,622 | 94,701 | 135,334 | 134,314 | 152,815 | 165,166 | 130,319 | 141,173 |
| River Roding and Branches | 667 | 375 | 1,058 | 791 | 524 | 219 | 284 | 271 | 1,010 | 704 | 601 | 499 | 470 | 271 |
| Mayes Brook and Tributaries | 25 | 15 | 30 | 7 | 7 | 6 | 13 | 18 | 28 | 35 | 29 | 17 | 17 | 17 |
| Stream Entering at Horse Shoe Corner | 47 | 43 | 40 | 40 | 40 | 43 | 43 | 43 | 41 | 54 | 47 | 43 | 43 | 43 |
| River Beam, and Stream between Rivers Beam and Ingreborne | 233 | 226 | 105 | 51 | 51 | 90 | 140 | 56 | 389 | 265 | 267 | 128 | 188 | 205 |
| River Ingreborne | 273 | 172 | 149 | 145 | 149 | 149 | 149 | 149 | 295 | 391 | 278 | 165 | 191 | 185 |
| Stream entering at Erith Reach and Streams at Wennington | 3 | 3 | 1 | 2 | 2 | 2 | 3 | 3 | 14 | 3 | 2 | 2 | 3 | 1 |
| Mar Dyke | 130 | 130 | 141 | 158 | 147 | 111 | 111 | 94 | 186 | 29 | 288 | 184 | 151 | 87 |
| River Cray and Tributary | 2,429 | 2,050 | 2,174 | 1,638 | 2,112 | 1,899 | 2,268 | 2,593 | 5,029 | 2,143 | 2,112 | 2,174 | 2,364 | 1,869 |
| River Darent | 2,616 | 1,851 | 3,214 | 3,091 | 2,388 | 2,060 | 3,338 | 2,502 | 3,591 | 2,850 | 3,591 | 2,388 | 2,388 | 2,278 |
| Grays Chalk Quarries | 43 | 56 | 51 | Nil | 57 | 60 | 55 | 28 | 35 | Nil | Nil | 39 | 42 | 67 |
| Streams at Northfleet, Chadwell St. Mary, and Tilbury | 274 | 274 | 276 | 299 | 296 | 321 | 312 | 308 | 352 | 332 | 313 | 308 | 318 | 298 |
| Streams at Gravesend Reach, Higham, Mucking Creek, and Higham Creek | 46 | 54 | 54 | 53 | 66 | 44 | 56 | 48 | 115 | 62 | 49 | 65 | 57 | 55 |
| Streams at Stanford-le-Hope, and North of Stanford-le-Hope | 8 | 8 | 8 | 9 | 11 | 9 | 8 | 8 | 8 | 8 | 8 | 7 | 11 | 4 |
| Streams at Fobbing and North Fobbing | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Vange Wharf and Stream | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Stream at Pitsea Creek | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Streams at Cooling | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Wall End, Barking | 44 | 41 | 41 | 36 | 36 | 36 | 36 | 36 | 132 | 72 | 59 | 72 | 72 | 59 |
| Volume of Water Supply | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 16,090 | 15,476 | 15,476 | 15,476 | 15,476 |
| Estimated quantity from area not gauged, below Northern Outfall | 2,948 | 2,668 | 2,726 | 2,407 | 2,320 | 2,378 | 2,682 | 2,567 | 4,205 | 3,132 | 3,074 | 2,755 | 2,871 | 2,538 |
| | 154,372 | 157,745 | 182,940 | 176,634 | 189,299 | 135,747 | 134,210 | 129,515 | 166,854 | 160,484 | 179,009 | 189,488 | 154,981 | 164,626 |

TABLE No. 2.—*continued.*

| | 1882. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct. 5. | Oct. 6. | Oct. 7. | Oct. 8. | Oct. 9. | Oct. 10. | Oct. 11. | Oct. 12. | Oct. 13. | Oct. 14. | Oct. 15. | Oct. 16. | Oct. 17. | Oct. 18. |
| | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. |
| River Thames at Teddington | 105,177 | 108,234 | 102,877 | 91,800 | 101,439 | 97,352 | 105,320 | 113,784 | 111,593 | 187,012 | 140,607 | 153,711 | 288,430 | 308,929 |
| Stream entering at Strawberry Hill | 12 | 12 | 12 | 12 | 12 | 12 | 13 | 15 | 12 | 12 | 12 | 41 | 32 | 23 |
| Stream passing through Twickenham | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 30 | 3,956 | 1,973 | 491 |
| River Crane at Isleworth | 1,728 | 1,773 | 1,706 | 1,728 | 1,750 | 1,517 | 1,662 | 1,533 | 1,662 | 1,871 | 2,108 | 2,345 | 4,189 | 3,549 |
| River Brent and Grand Junction Canal | 243 | 323 | 319 | 81 | 293 | 323 | 212 | 440 | 417 | 323 | 130 | 2,292 | 3,860 | 1,521 |
| Stream entering at Chiswick | Nil | Nil | Nil | Nil | Nil | Nil | Nil | 2 | Nil | Nil | Nil | 62 | 27 | 8 |
| Beverley Brook | 27 | 48 | 38 | 38 | 33 | 33 | 46 | 192 | 76 | 50 | 29 | 718 | 462 | 298 |
| River Wandle | 2,794 | 3,004 | 2,875 | 3,182 | 3,175 | 2,751 | 3,296 | 3,064 | 2,759 | 2,158 | 2,699 | 4,059 | 3,733 | 2,818 |
| Regent's Canal and Limehouse Cut | 211 | 204 | 171 | Nil | 130 | 189 | 212 | 180 | 106 | 133 | Nil | 103 | 134 | 128 |
| River Ravensborne | 806 | 519 | 895 | 387 | 657 | 806 | 806 | 1,082 | 1,161 | 616 | 509 | 2,871 | 2,378 | 1,566 |
| River Lea | 2,151 | 2,097 | 2,072 | 1,369 | 1,893 | 1,929 | 2,029 | 2,185 | 3,051 | 3,671 | 2,041 | 1,591 | 8,137 | 7,271 |
| Estimated quantity from area not gauged, above Northern Outfall | 2,558 | 2,558 | 2,641 | 2,363 | 2,686 | 2,525 | 2,730 | 2,728 | 2,755 | 2,737 | 2,416 | 4,305 | 5,825 | 4,728 |
| Total above Northern Outfall | 115,711 | 118,776 | 113,610 | 100,964 | 112,072 | 107,441 | 116,330 | 125,209 | 123,596 | 198,587 | 150,581 | 176,051 | 319,180 | 331,330 |
| River Roding and Branches | 360 | 341 | 1,062 | 307 | 437 | 283 | 556 | 681 | 421 | 442 | 1,087 | 1,266 | 3,104 | 5,367 |
| Mayes Brook and Tributaries | 18 | 15 | 15 | 16 | 41 | 11 | 11 | 18 | 30 | 24 | 23 | 35 | 113 | 73 |
| Stream entering at Horse Shoe Corner | 43 | 47 | 43 | 43 | 43 | 43 | 43 | 54 | 47 | 47 | 47 | 54 | 72 | 49 |
| River Beam, and Stream between Rivers Beam and Ingreborne | 196 | 184 | 138 | 97 | 131 | 131 | 97 | 317 | 276 | 327 | 69 | 485 | 188 | 594 |
| River Ingreborne | 145 | 151 | 151 | 145 | 164 | 145 | 151 | 330 | 340 | 310 | 230 | 236 | 1,950 | 771 |
| Stream entering at Erith Reach and Stream at Wennington | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 4 | 3 | 1 | 1 | 5 | 149 | 69 |
| Mar Dyke | 104 | 110 | 110 | 92 | 111 | 104 | 104 | 110 | 187 | 110 | 104 | 110 | 3,725 | 25 |
| River Cray and Tributary | 2,364 | 2,396 | 2,560 | 1,638 | 2,205 | 2,396 | 2,461 | 2,626 | 1,695 | 2,364 | 1,526 | 5,399 | 2,396 | 2,332 |
| River Darent | 2,616 | 2,616 | 2,388 | 3,091 | 3,851 | 2,850 | 3,591 | 2,388 | 3,214 | 2,850 | 1,955 | 3,091 | 4,948 | 4,948 |
| Grays Chalk Quarries | 67 | 67 | 47 | 16 | 52 | 58 | 56 | 57 | 49 | 49 | 11 | 53 | 30 | 44 |
| Streams at Northfleet, Chadwell St. Mary, and Tilbury | 277 | 256 | 282 | 257 | 279 | 280 | 291 | 323 | 322 | 321 | 297 | 316 | 443 | 316 |
| Streams at Gravesend Reach, Higham, Mucking Creek and Higham Creek | 70 | 71 | 64 | 70 | 68 | 68 | 68 | 68 | 67 | 68 | 73 | 80 | 86 | 66 |
| Streams at Stanford-le-Hope, and North of Stanford-le-Hope | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 11 | 11 | 13 | 13 | 142 | 312 | 81 |
| Streams at Fobbing and North of Fobbing | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | 1 | 1 | 3 | 7 |
| Vange Wharf and Stream | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | 9 | 5 |
| Stream at Pitsea Creek | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Streams at Cooling | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil | Nil |
| Wall End, Barking | 47 | 36 | 30 | 30 | 30 | 30 | 30 | 47 | 53 | 36 | 36 | 53 | 59 | 598 |
| Volume of Water Supply | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 |
| Estimated quantity from area not gauged, below Northern Outfall | 2,668 | 2,668 | 2,755 | 2,465 | 2,802 | 2,634 | 2,848 | 2,858 | 2,874 | 2,854 | 2,520 | 4,490 | 6,076 | 4,931 |
| | 140,172 | 143,220 | 138,742 | 124,717 | 137,772 | 131,960 | 142,123 | 150,577 | 148,661 | 223,879 | 174,050 | 207,343 | 358,319 | 367,082 |

TABLE No. 2.—*continued.*

| | 1882. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Oct. 19. | Oct. 20. | Oct. 21. | Oct. 22. | Oct. 23. | Oct. 24. | Oct. 25. | Oct. 26. | Oct. 27. | Oct. 28. | Oct. 29. | Oct. 30. | Oct. 31. | Nov. 1. |
| | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. |
| River Thames at Teddington | 281,846 | 276,571 | 300,586 | 400,512 | 465,635 | 427,395 | 443,092 | 484,356 | 512,193 | 558,270 | 813,273 | 1,053,798 | 891,625 | 840,235 |
| Stream entering at Strawberry Hill | 18 | 20 | 27 | 53 | 24 | 35 | 27 | 25 | 31 | 80 | 59 | 48 | 67 | 63 |
| Stream passing through Twickenham | 400 | 800 | 800 | 6,400 | 1,200 | 1,800 | 1,600 | 1,319 | 1,580 | 7,100 | 2,400 | 2,200 | 1,900 | 1,589 |
| River Crane at Isleworth | 3,197 | 3,198 | 3,926 | 3,913 | 3,900 | 2,967 | 3,793 | 4,084 | 4,386 | 4,146 | 18,500 | 6,200 | 5,600 | 4,352 |
| River Brent and Grand Junction Canal | 716 | 1,097 | 1,292 | 5,769 | 3,789 | 4,965 | 14,879 | 3,152 | 8,028 | 11,104 | 42,522 | 7,250 | 20,797 | 6,621 |
| Stream entering at Chiswick | 2 | 14 | 31 | 83 | 35 | 94 | 62 | 52 | 82 | 234 | 225 | 196 | 175 | 110 |
| Beverley Brook | 213 | 298 | 409 | 1,217 | 430 | 1,388 | 1,168 | 821 | 1,081 | 6,289 | 5,120 | 2,890 | 2,263 | 1,323 |
| River Wandle | 2,396 | 2,497 | 2,855 | 4,214 | 3,547 | 8,567 | 3,614 | 3,570 | 4,624 | 20,427 | 6,901 | 5,607 | 5,023 | 4,520 |
| Regent's Canal and Limehouse Cut | 199 | 142 | 137 | Nil | 207 | 383 | 246 | 374 | 401 | 525 | Nil | 327 | 521 | 416 |
| River Ravensborne | 1,588 | 1,260 | 998 | 4,483 | 1,785 | 2,411 | 2,640 | 1,260 | 2,544 | 2,845 | 2,829 | 4,251 | 7,032 | 3,740 |
| River Lea | 6,730 | 8,296 | 7,458 | 16,045 | 33,248 | 30,876 | 52,527 | 55,354 | 36,236 | 38,992 | 80,425 | 83,108 | 67,551 | 51,349 |
| Estimated quantity from area not gauged, above Northern Outfall | 3·835 | 4,499 | 4,560 | 10,372 | 10,048 | 12,621 | 14,840 | 13,239 | 13,132 | 19,225 | 26,756 | 22,686 | 20,986 | 14,938 |
| Total above Northern Outfall | 301,140 | 298,692 | 323,079 | 453,061 | 523,848 | 493,502 | 538,488 | 567,606 | 584,318 | 669,237 | 999,010 | 1,188,561 | 1,023,540 | 929,256 |
| River Roding and Branches | 2,389 | 3,238 | 3,403 | 10,775 | 13,179 | 15,035 | 20,329 | 20,377 | 29,792 | 33,357 | 32,945 | 41,172 | 37,083 | 31,199 |
| Mayes Brook and Tributaries | 52 | 98 | 67 | 120 | 123 | 39 | 207 | 128 | 271 | 164 | 892 | 392 | 601 | 351 |
| Stream entering at Horse Shoe Corner | 38 | Nil | 20 | 69 | 50 | 90 | 69 | 58 | 76 | 101 | 162 | 151 | 151 | 72 |
| River Beam, and Stream between Rivers Beam and Ingreborne | 393 | 1,756 | 631 | 4,909 | 1,211 | 4,534 | 3,393 | 1,298 | 1,984 | 5,128 | 8,901 | 6,915 | 3,871 | 1,747 |
| River Ingreborne | 543 | 1,736 | 1,003 | 4,140 | 2,041 | 3,389 | 5,255 | 2,664 | 3,526 | 3,882 | 5,363 | 5,946 | 6,356 | 4,327 |
| Stream entering at Erith Reach and Stream at Wennington | 94 | 4 | 142 | 276 | 208 | 230 | 260 | 187 | 213 | 919 | 866 | 218 | 246 | 523 |
| Mar Dyke | 213 | 960 | 2,016 | 3,456 | 1,728 | 4,512 | 2,256 | 2,016 | 2,016 | 4,320 | 4,512 | 4,704 | 5,856 | 2,496 |
| River Cray and Tributary | 2,626 | 1,899 | 1,928 | 4,500 | 1,667 | 9,278 | 4,610 | 5,153 | 2,232 | 10,816 | 2,593 | 9,150 | 2,427 | 2,116 |
| River Darent | 2,970 | 2,850 | 3,591 | 10,259 | 9,646 | 8,742 | 2,431 | 3,690 | 4,948 | 5,852 | 6,755 | 5,250 | 4,811 | 3,338 |
| Grays Chalk Quarries | 11 | 57 | 38 | 6 | 37 | 56 | 55 | 45 | 41 | 11 | 11 | 1,209 | 26 | 355 |
| Streams at Northfleet, Chadwell St. Mary, and Tilbury | 297 | 297 | 340 | 318 | 318 | 383 | 354 | 362 | 362 | 393 | 352 | 402 | 413 | 408 |
| Streams at Gravesend Reach, Higham, Mucking Creek and Higham Creek | 73 | 90 | 148 | 215 | 113 | 628 | 162 | 114 | 78 | 600 | 260 | 100 | 129 | 108 |
| Streams at Stanford-le-Hope, and North of Stanford-le-Hope | 75 | 382 | 79 | 373 | 215 | 95 | 223 | 153 | 314 | 419 | 443 | 219 | 386 | 210 |
| Streams at Fobbing and North of Fobbing | 2 | 9 | 23 | 29 | 34 | 362 | 65 | 133 | 512 | 73 | 170 | 91 | 15 | 9 |
| Vange Wharf and Stream | 8 | 11 | 34 | 18 | 53 | 38 | 38 | 35 | 136 | 186 | 40 | 46 | 11 | Nil |
| Stream at Pitsea Creek | 6 | 5 | 10 | 15 | 62 | 103 | 20 | 52 | 52 | 163 | 78 | 65 | 36 | 5 |
| Streams at Cooling | Nil | Nil | 75 | 71 | 68 | 100 | 100 | 75 | 75 | 80 | 75 | 109 | 153 | 89 |
| Wall End, Barking | 53 | 79 | 86 | 101 | 101 | 176 | 79 | 72 | 72 | 176 | 108 | 86 | 108 | 79 |
| Volume of Water Supply | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,476 | 15,012 |
| Estimated quantity from area not gauged, below Northern Outfall | 4,001 | 4,693 | 4,756 | 10,819 | 10,480 | 13,165 | 15,479 | 13,810 | 13,697 | 20,053 | 27,909 | 23,662 | 21,890 | 15,581 |
| | 330,460 | 332,282 | 356,945 | 519,006 | 580,698 | 599,933 | 609,349 | 633,504 | 660,191 | 771,406 | 1,106,921 | 1,303,924 | 1,123,585 | 1,007,281 |

TABLE No. 2—*continued.*

| | 1882. | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov. 2. | Nov. 3. | Nov. 4. | Nov. 5. | Nov. 6. | Nov. 7. | Nov. 8. | Nov. 9. | Nov. 10. | Nov. 11. | Nov. 12. | Nov. 13. | Nov. 14. | Nov. 15. |
| | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. |
| River Thames at Teddington | 756,192 | 711,100 | 627,547 | 578,217 | 502,128 | 491,339 | 558,410 | 577,096 | 560,853 | 583,622 | 644,814 | 640,678 | 649,723 | 621,542 |
| Stream entering at Strawberry Hill | 52 | 55 | 48 | 48 | 48 | 57 | 59 | 55 | 55 | 55 | 52 | 52 | 48 | 48 |
| Stream passing through Twickenham | 600 | 524 | 520 | 420 | 450 | 1,820 | 2,000 | 1,766 | 400 | 490 | 350 | 340 | 390 | 400 |
| River Crane at Isleworth | 5,142 | 4,345 | 4,924 | 4,735 | 4,551 | 4,174 | 4,404 | 3,684 | 3,337 | 3,933 | 4,022 | 4,070 | 3,978 | 3,402 |
| River Brent and Grand Junction Canal | 4,494 | 5,377 | 3,801 | 2,221 | 1,737 | 11,159 | 18,560 | 5,217 | 2,307 | 2,287 | 1,003 | 999 | 842 | 1,046 |
| Stream entering at Chiswick | 72 | 62 | 52 | 43 | 39 | 35 | 88 | 43 | 35 | 27 | 23 | 20 | 17 | 14 |
| Beverley Brook | 1,135 | 1,164 | 1,131 | 1,164 | 1,311 | 1,261 | 1,279 | 1,343 | 1,017 | 1,372 | 1,343 | 1,343 | 1,343 | 1,252 |
| River Wandle | 3,789 | 3,973 | 3,918 | 3,164 | 3,373 | 4,774 | 4,948 | 4,065 | 2,805 | 3,280 | 2,413 | 2,364 | 2,757 | 2,809 |
| Regent's Canal and Limehouse Cut | 494 | 472 | 550 | 1,241 | 223 | 230 | 466 | 428 | 458 | 352 | 183 | 300 | 582 | 644 |
| River Ravensborne | 3,171 | 3,249 | 3,826 | 3,249 | 3,026 | 1,566 | 4,846 | 2,507 | 1,785 | 895 | 977 | 1,358 | 1,363 | 1,358 |
| River Lea | 33,440 | 26,187 | 18,897 | 25,354 | 19,542 | 22,984 | 55,497 | 44,762 | 33,602 | 23,322 | 9,681 | 6,229 | 5,669 | 4,296 |
| Estimated quantity from area not gauged above Northern Outfall | 10,202 | 8,449 | 6,903 | 7,520 | 6,643 | 8,890 | 15,443 | 11,593 | 8,674 | 7,145 | 4,518 | 4,253 | 4,337 | 4,073 |
| Total above Northern Outfall | 818,783 | 764,957 | 672,117 | 627,376 | 543,107 | 548,289 | 666,000 | 653,459 | 605,328 | 626,780 | 669,379 | 662,006 | 671,049 | 640,884 |
| River Roding and Branches | 14,473 | 7,904 | 5,061 | 5,631 | 4,861 | 5,826 | 15,597 | 12,774 | 9,837 | 7,132 | 3,542 | 2,634 | 2,487 | 2,125 |
| Mayes Brook and Tributaries | 210 | 195 | 195 | 146 | 138 | 168 | 223 | 95 | 189 | 141 | 71 | 71 | 72 | 72 |
| Stream entering at Horse Shoe Corner | 66 | Nil | 63 | 61 | 61 | 61 | 66 | 63 | 66 | 61 | 58 | Nil | 58 | 55 |
| River Beam and Stream between Rivers Beam and Ingreborne | 1,376 | 1,023 | 964 | 829 | 923 | 1,838 | 4,966 | 1,410 | 857 | 816 | 732 | 660 | 605 | 592 |
| River Ingreborne | 2,612 | 1,916 | 1,319 | 800 | 694 | 1,488 | 496 | 2,327 | 1,510 | 1,042 | 726 | 724 | 647 | 531 |
| Stream entering at Erith Reach and Stream at Wennington | 477 | 459 | 318 | 198 | 243 | 243 | 494 | 200 | 383 | 202 | 208 | 201 | 203 | 203 |
| Mar Dyke | 880 | 720 | 720 | 640 | 560 | 720 | 3,744 | 2,304 | 640 | 640 | 480 | 480 | 480 | 340 |
| River Cray and Tributary | 1,678 | 1,933 | 2,237 | 2,113 | 2,427 | 2,492 | 2,363 | 2,459 | 2,175 | 2,459 | 1,592 | 2,212 | 2,664 | 2,264 |
| River Darent | 4,388 | 4,388 | 2,850 | 4,665 | 4,665 | 6,442 | 5,068 | 6,132 | 4,948 | 4,388 | 3,338 | 4,388 | 4,948 | 4,948 |
| Grays Chalk Quarries | 1,294 | 756 | Nil | 6 | 6 | 1,192 | 123 | 305 | 239 | 539 | 6 | 6 | 6 | 565 |
| Streams at Northfleet, Chadwell St. Mary, and Tilbury | 362 | 340 | 297 | 295 | 317 | 335 | 317 | 303 | 362 | 362 | 340 | 385 | 388 | 388 |
| Streams at Gravesend Reach, Higham, Mucking Creek, and Higham Creek | 82 | 94 | 108 | 107 | 128 | 128 | 113 | 93 | 91 | 105 | 121 | 116 | 100 | 107 |
| Streams at Stanford-le Hope and North of Stanford-le-Hope | 120 | 99 | 88 | 80 | 69 | 40 | 40 | 86 | 119 | 96 | 71 | 78 | 70 | 59 |
| Streams at Fobbing and North of Fobbing | 7 | 31 | 32 | 9 | 252 | 36 | 12 | 3 | 3 | 5 | 23 | 3 | Nil | Nil |
| Vange Wharf and Stream | Nil | Nil | Nil | 1 | Nil | 1 | 1 | 7 | 2 | 1 | 5 | Nil | Nil | Nil |
| Stream at Pitsea Creek | Nil | Nil | 16 | 53 | 14 | 6 | 7 | 5 | 3 | 6 | 3 | Nil | Nil | Nil |
| Streams at Cooling | 104 | 96 | 67 | 67 | 65 | 88 | 75 | 57 | 43 | 33 | 38 | 43 | 38 | 37 |
| Wall End, Barking | 47 | 36 | 30 | 28 | 30 | 47 | 108 | 72 | 53 | 47 | 40 | 52 | 47 | 41 |
| Volume of Water Supply | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 |
| Estimated quantity from area not gauged below Northern Outfall | 10,642 | 8,812 | 7,200 | 7,843 | 6,929 | 9,272 | 16,110 | 12,093 | 9,048 | 7,453 | 4,713 | 4,437 | 4,524 | 4,249 |
| | 872,613 | 808,771 | 708,694 | 665,960 | 580,501 | 593,724 | 730,935 | 709,259 | 650,908 | 667,320 | 700,498 | 693,508 | 703,398 | 672,472 |

TABLE No. 2.—*continued.*

| | 1882. | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Nov. 16. | Nov. 17. | Nov. 18. | Nov. 19. | Nov. 20. | Nov. 21. | Nov. 22. | Nov. 23. | Nov. 24. | Nov. 25. | Nov. 26. | Nov. 27. | Nov. 28. | Nov. 29. | Nov. 30. |
| | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. | Cube Feet per Minute. |
| River Thames at Teddington | 565,098 | 560,757 | 541,753 | 536,940 | 530,785 | 515,709 | 511,720 | 489,072 | 506,365 | 512,060 | 496,570 | 459,869 | 403,376 | 440,093 | 476,345 |
| Stream entering at Strawberry Hill | 52 | 52 | 52 | 52 | 52 | 50 | 48 | 48 | 59 | 52 | 52 | 52 | 52 | 55 | 52 |
| Stream passing through Twickenham | 800 | 1,200 | 48 | 47 | 522 | 490 | 500 | 500 | 530 | 1,440 | 510 | 600 | 48 | 51 | 48 |
| River Crane at Isleworth | 3,928 | 3,795 | 3,785 | 3,899 | 4,012 | 3,593 | 2,541 | 2,734 | 3,005 | 3,074 | 3,052 | 3,029 | 2,616 | 4,002 | 3,603 |
| River Brent and Grand Junction Canal | 2,256 | 2,282 | 3,431 | 19,575 | 5,217 | 3,701 | 2,264 | 5,421 | 11,719 | 5,229 | 3,750 | 2,021 | 1,741 | 2,319 | 4,961 |
| Stream entering at Chiswick | 43 | 52 | 35 | 27 | 23 | 23 | 31 | 27 | 23 | 20 | 17 | 17 | 17 | 20 | 17 |
| Beverley Brook | 1,343 | 1,960 | 1,311 | 1,342 | 1,279 | 1,225 | 1,225 | 1,225 | 1,311 | 1,279 | 1,279 | 1,475 | 1,300 | 1,279 | 1,275 |
| River Wandle | 4,126 | 5,808 | 3,260 | 3,175 | 3,935 | 3,402 | 3,561 | 3,562 | 4,006 | 4,420 | 3,594 | 3,754 | 3,240 | 3,594 | 3,210 |
| Regent's Canal and Limehouse Cut | 370 | 588 | 354 | Nil | 316 | 530 | 477 | 312 | 463 | 473 | 178 | 426 | 571 | 606 | 408 |
| River Ravensborne | 7,446 | 3,731 | 1,473 | 2,014 | 2,163 | 1,790 | 2,378 | 1,899 | 8,477 | 1,256 | 1,566 | 1,675 | 813 | 2,378 | 1,675 |
| River Lea | 11,506 | 54,350 | 73,258 | 43,641 | 38,598 | 35,557 | 37,402 | 30,888 | 27,413 | 29 027 | 28,817 | 22,066 | 13,729 | 13,705 | 18,585 |
| Estimated quantity from area not gauged, above Northern Outfall | 9,299 | 14,011 | 16,082 | 12,760 | 10,703 | 9,661 | 9,688 | 8,966 | 11,148 | 9,244 | 7,965 | 6,950 | 5,810 | 6,074 | 6,867 |
| Total above Northern Outfall | 606,267 | 648,586 | 644,842 | 623,472 | 597,605 | 575,731 | 571,835 | 544,474 | 574,519 | 567,574 | 547,350 | 501,934 | 433,313 | 474.176 | 517,046 |
| River Roding and Branches | 4,023 | 15,297 | 20,273 | 12,479 | 11,152 | 10,352 | 10,837 | 9,123 | 8,209 | 8,633 | 8,578 | 6,786 | 4,608 | 4,601 | 5,885 |
| Mayes Brook and Tributaries | 119 | 130 | 128 | 109 | 172 | 132 | 146 | 164 | 172 | 133 | 105 | 69 | 61 | 69 | 127 |
| Stream entering at Horse Shoe Corner | 69 | 152 | 69 | 63 | 63 | 58 | 61 | 61 | 61 | 61 | 61 | 58 | 58 | 51 | 58 |
| River Beam, and Stream between Rivers Beam and Ingreborne | 4,889 | 2,466 | 11,966 | 3,145 | 1,895 | 2,251 | 1,469 | 1,528 | 1,921 | 1,893 | 1,587 | 888 | 759 | 2,196 | 1,694 |
| River Ingreborne | 3,710 | 6,197 | 3,508 | 3,057 | 2,362 | 2,417 | 1,830 | 1,278 | 2,526 | 1,528 | 1,482 | 995 | 778 | 790 | 1,150 |
| Stream entering at Erith Reach and Stream at Wennington | 785 | 722 | 354 | 379 | 372 | 200 | 204 | 209 | 383 | 243 | 201 | 185 | 168 | 192 | 172 |
| Mar Dyke | 3,581 | 7,312 | 1,808 | 2,909 | 1,632 | 2,698 | 1,978 | 1,978 | 3,773 | 1,865 | 712 | 496 | 372 | 336 | 672 |
| River Cray and Tributary | 17,296 | 2,689 | 2,623 | 1,893 | 2,427 | 2,237 | 2,206 | 1,873 | 5,414 | 2,590 | 1,620 | 2,434 | 2,338 | 2,402 | 2,088 |
| River Darent | 5,428 | 3,338 | 2,388 | 4,607 | 6,756 | 4,388 | 4,948 | 4,948 | 7,399 | 7,399 | 3,338 | 3,851 | 7,399 | 4,948 | 4,806 |
| Grays Chalk Quarries | 125 | 234 | 425 | 6 | 949 | 6 | 1,042 | 1,421 | 741 | 792 | 6 | 665 | 1,240 | 539 | 501 |
| Streams at Northfleet, Chadwell St. Mary, and Tilbury | 377 | 390 | 360 | 365 | 352 | 354 | 357 | 394 | 399 | 379 | 382 | 383 | 385 | 378 | 378 |
| Streams at Gravesend Reach, Higham, Mucking Creek, and Higham Creek | 119 | 161 | 175 | 176 | 152 | 91 | 105 | 76 | 179 | 130 | 91 | 91 | 95 | 139 | 107 |
| Streams at Stanford-le-Hope, and North of Stanford-le-Hope | 200 | 326 | 131 | 140 | 126 | 120 | 318 | 198 | 318 | 198 | 137 | 98 | 74 | 125 | 104 |
| Streams at Fobbing and North of Fobbing | 3 | 26 | 21 | 33 | 20 | 10 | 4 | 2 | 3 | 2 | 1 | 1 | Nil | Nil | 5 |
| Stream at Vange Wharf | 10 | 10 | 13 | 19 | 9 | 10 | 10 | 9 | 2 | 2 | 1 | Nil | Nil | Nil | 1 |
| Stream at Pitsea Creek | Nil | 5 | 7 | 13 | 7 | Nil | Nil | 5 | 2 | 2 | 2 | 2 | 2 | Nil | Nil |
| Streams at Cooling | 47 | 149 | 92 | 96 | 105 | 98 | 87 | 95 | 117 | 90 | 73 | 52 | 55 | 62 | 66 |
| Wall End, Barking | 101 | 108 | 101 | 86 | 86 | 72 | 72 | 63 | 86 | 79 | 72 | 79 | 65 | 86 | 86 |
| Volume of Water Supply | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 | 15,012 |
| Estimated quantity from area not gauged, below Northern Outfall | 9 701 | 14,616 | 16,777 | 13,311 | 11,165 | 10,078 | 10,107 | 9,353 | 11,629 | 9,643 | 8.309 | 7,250 | 6,061 | 6,337 | 7,163 |
| | 671,862 | 717,926 | 721,073 | 680,770 | 652,549 | 626,315 | 622,628 | 592,264 | 632,865 | 618,248 | 589,120 | 541,329 | 472,843 | 512,449 | 557,121 |

## APPENDIX U.



*(Put in by Mr. Baldwin Latham, 24th January 1883. See Q. 7525.)*

FORMULÆ for the DETERMINATION from CHLORINE ANALYSES of the RATIO of the FRESH WATER to the SEA WATER in a SAMPLE of the MIXTURE.

Let $a$ represent the amount of chlorine in one volume of sea water.
,, $b$ ,, the amount in an equal volume of fresh water.
,, $c$ ,, the amount in the sample.

Then, if a mixture be made of sea water and fresh water, the amount of chlorine in the mixture will be equal to the volumes of sea water and fresh water multiplied by $a$ and $b$ respectively.

Also, if a mixed sample of sea water and fresh water in unknown proportions be taken, then the component volume of sea water, whatever it may be, multiplied by $a$, together with the volume of fresh water multiplied by $b$, will represent the total amount of chlorine in the mixed sample; that is, will be equal to the volume of the sample multiplied by $c$, or, what is equivalent, the sum of the component volumes of sea water and fresh water multiplied by $c$.

In the sample suppose $V_s$ and $V_r$ to represent the component volumes of sea water and river water respectively, then—

$$V_s \times a + V_r \times b = (V_s + V_r) \times c;$$
$$V_s a + V_r b = (V_s + V_r) c;$$
$$V_s a + V_r b = V_s c + V_r c;$$
$$V_s a - V_s c = V_r c - V_r b;$$
$$V_s (a - c) = V_r (c - b);$$
$$a - c = \frac{V_r}{V_s} (c - b);$$
$$\frac{a - c}{c - b} = \frac{V_r}{V_s}.$$

$\frac{V_r}{V_s}$ represents the ratio in the mixed sample that the fresh water bears to the sea water.

Therefore, in the sample, the ratio of the fresh water to the sea water is equal to $\frac{a - c}{c - b}$.

*Example.*—Suppose a sample, on analysis, was found to contain 251·42 parts of chlorine in 100,000 parts, and that it consists entirely of fresh water and sea water.

Consider the amount of 100,000 parts as the volume of the sample:—

$a$, the chlorine in the component sea water is taken at 1,961 parts per 100,000;

$b$, the chlorine in the fresh water is taken at 1·7 parts per 100,000;

$c$ is found by analysis to be 251·42;

then,—

$a - c = 1961 - 251{\cdot}42 = 1709{\cdot}58$;

$c - b = 251{\cdot}42 - 1{\cdot}7 = 249{\cdot}72$;

the ratio of the fresh water to the sea water $\frac{a - c}{c - b}$ is equal to $1709{\cdot}58 \div 249{\cdot}72 = 6{\cdot}8459875$, &c.; therefore the ratio of the fresh water to the sea water in the sample is 6·8459875 : 1.

*Proof.*—If the sample be re-mixed in these proportions it will be found to contain 251·42 parts of chlorine per volume of 100,000 parts.

The ratio of the fresh water to the sea water is 6·8459875 : 1.

| | Chloriné. |
|---|---|
| 6·8459875 volumes of fresh water at 1·7 parts per volume = | 11·63817875 |
| 1 volume of sea water at 1,961 parts per volume = | 1961·0000 |
| Therefore the mixture of 7·8459875 volumes contains = | 1972·63817875 |

$1972{\cdot}63817875 \div 7{\cdot}8459875 = 251{\cdot}4200$;

thus showing that the sample on being re-mixed in the above proportion would contain 251·42 parts of chlorine.

It will be seen from this proof that no other ratio of composition would give a mixture containing 251·42 parts of chlorine, for, as the ratio of fresh water to the sea water increases, the chlorine in the mixture necessarily diminishes, as may be seen, thus:—

If the ratio be 5 : 1

| | Chlorine. |
|---|---|
| 5 volumes fresh water at 1·7 = | 8·5 |
| 1 volume sea water at 1961 = | 1961·0 |
| the mixture of 6 volumes contains | 1969·5 |

and 1 volume contains 328·2 parts chlorine.

If the ratio be 6 : 1

| | Chlorine. |
|---|---|
| 6 volumes fresh water at 1·7 = | 10·2 |
| 1 volume sea water at 1961 = | 1961·0 |
| the mixture of 7 volumes contains | 1971·2 |

and 1 volume contains 281·6 parts chlorine.

If the ratio be 6·8, &c. : 1 (as before),
one volume of the mixture contains 251·4 parts chlorine, and so on, varying in inverse quantities to the ratio. Therefore there is only one ratio of composition which will produce a mixture containing a given amount of chlorine.

When sewage is mixed with river water in a known proportion, and consequently the quantity of chlorine per 100,000 parts of the mixture is known, the ratio of the river water and sewage combined to the sea water can be determined in the same manner as above, calling $b$ the quantity of chlorine in one volume of river water and sewage combined.

# APPENDIX A.C.

*Put in by Mr. Baldwin Latham. See Q. 7787.*

TABLE showing the RESULT of EXPERIMENTS CONDUCTED by Mr. BALDWIN LATHAM, C.E., at CROYDON, upon the RATE AT WHICH RAIN FALLS, and the EXTENT to which the MAXIMUM FALL of RAIN AFFECTS the FLOW in the SEWERS of CROYDON.

### MAY 1879.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | ·13 | ·08 | 45 | 2·56 | 6-7 p.m. | 5·1 | 8-9 p.m. |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | ·175 | ·10 | 60 | 2·4 | 6-8 a.m. | 4·9 | 8-9 a.m. |
| 6 | ·015 | ·01 | 5 | 2·88 | 9-10 a.m. | 4·7 | 9-10 a.m. |
| 7 | — | — | — | — | — | — | — |
| 8 | ·005 | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | ·065 | ·035 | 60 | ·84 | 10 a.m.–12 | 4·3 | 11 a.m.–12 |
| 12 | — | — | — | — | — | — | — |
| 13 | ·01 | ·01 | 30 | ·48 | 11 p.m.–12 | 3·6 | 12–1 a.m. |
| 14 | ·055 | ·02 | 5 | 5·76 | 12–1 p.m. | 4·3 | 2–3 p.m. |
| 15 | ·305 | ·09 | 40 | 3·24 | 10–11 p.m. | 4·4 | 11–12 p.m. |
| 16 | — | — | — | — | — | — | — |
| 17 | ·135 | ·03 | 50 | ·864 | 9–10 p.m. | 3·8 | 11 p.m.–12 |
| 18 | ·015 | ·005 | 5 | 1·44 | 11 a.m.–12 | 4·0 | 12–1 p.m. |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | ·165 | ·09 | 40 | 3·24 | 2–3 a.m. | 4·4 | 3–4 a.m |
| 23 | ·10 | ·065 | 5 | 18·72 | 11 a.m.–12 | 3·7 | 12–1 p.m. |
| 24 | ·25 | ·115 | 60 | 2·76 | 5–7 a.m. | 4·4 | 7–8 a.m. |
| 25 | ·005 | — | — | — | — | — | — |
| 26 | ·175 | ·04 | 20 | 2·88 | 4–5 a.m. | 3·8 | 5–6 a.m. |
| 27 | ·37 | ·08 | 30 | 3·84 | 1–2 a.m. | 5·4 | 3–4 a.m. |
| 28 | 1·51 | ·50 | 60 | 12·0 | 10–11 p.m. | 10·6 | 10–11 p.m. |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | ·115 | ·10 | 40 | 3·6 | 12·2 p.m. | 5·1 | 1–2 p.m. |

### JUNE 1879.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | ·20 | ·11 | 60 | 2·64 | 7-9 p.m. | 5·0 | 8-9 p.m. |
| 2 | ·425 | ·08 | 45 | 2·56 | 11 p.m.–1 a.m. | 4·7 | 12-1 a.m. |
| 3 | ·025 | ·02 | 5 | 5·76 | 12-1 p.m. | 4·1 | 1-2 p.m. |
| 4 | — | — | — | — | — | — | — |
| 5 | ·135 | ·12 | 40 | 4·32 | 1-2 a.m. | 3·8 | 2-3 a.m. |
| 6 | — | — | — | — | — | — | — |
| 7 | ·30 | ·165 | 60 | 3·96 | 5-6 p.m. | 6·7 | 6-7 p.m. |
| 8 | ·04 | ·03 | 5 | 8·64 | 12 1 p.m. | 4·0 | 1-2 p.m. |
| 9 | ·02 | ·01 | 5 | 2·88 | 9-10 a.m. | 4·3 | 10-11 a.m. |
| 10 | — | — | — | — | — | — | — |
| 11 | ·28 | ·10 | 10 | 14·40 | 4-5 p.m. | 6·7 | 4-5 p.m. |
| 12 | ·18 | ·09 | 10 | 12·96 | 11 a.m.–12 | 4·9 | 12-1 p.m. |
| 13 | — | — | — | — | — | — | — |
| 14 | ·09 | ·065 | 60 | 1·56 | 7-8 a.m. | 4·7 | 8-9 a.m. |
| 15 | ·035 | ·025 | 30 | 1·20 | 12-1 p m. | 4·4 | 1-2 p.m. |
| 16 | ·165 | ·11 | 60 | 2·64 | 9-11 a.m. | 5·8 | 10-11 a.m. |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | ·065 | ·04 | 30 | 1·92 | 5-6 a.m. | 4·3 | 6-7 a.m. |
| 20 | ·11 | ·065 | 40 | 2·34 | 7-9 a.m. | 4·3 | 8-9 a.m. |
| 21 | ·095 | ·05 | 40 | 1·80 | 11 a.m.–12 | 4·5 | 11 a.m.–12 |
| 22 | — | — | — | — | — | — | — |
| 23 | ·045 | ·045 | 20 | 3·24 | 5-6 a.m. | 4·0 | 6-7 a.m. |
| 24 | ·795 | ·25 | 60 | 6·00 | 6-8 a.m. | 7·7 | 7-8 a.m. |
| 25 | ·135 | ·115 | 30 | 5·52 | 9-10 a.m. | 7·0 | 10-11 a.m. |
| 26 | ·08 | ·03 | 15 | 2·88 | 9-10 a.m. | 3·8 | 10-11 a.m. |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | ·32 | ·11 | 60 | 2·64 | 6-7 a.m. | 4·8 | 7-8 a.m. |

### JULY 1879.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | ·515 | ·21 | 60 | 5·01 | 9-10 a.m. | 7·5 | 10-11 a.m. |
| 2 | ·31 | ·08 | 15 | 7·68 | 8-9 p.m. | 4·9 | 8-9 p.m. |
| 3 | ·12 | ·07 | 10 | 10·08 | 1-2 p.m. | 4·8 | 2-3 p.m. |
| 4 | ·12 | ·05 | 10 | 7·20 | 1-2 p.m. | 4·5 | 2-3 p.m. |
| 5 | ·04 | ·01 | 5 | 2·88 | 6-7 p.m. | 4·2 | 7-8 p.m. |
| 6 | ·225 | ·07 | 50 | 2·016 | 3-5 p.m. | 4·3 | 5-6 p.m. |
| 7 | — | — | — | — | — | — | — |
| 8 | ·065 | ·025 | 5 | 7·2 | 4-5 p.m. | 4·3 | 4-5 p.m. |
| 9 | ·185 | ·09 | 30 | 4·32 | 9-10 p.m. | 5·6 | 10-11 p.m, |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | ·045 | ·01 | 20 | ·72 | 8-9 p.m. | 3·7 | 9-10 p.m. |
| 13 | ·045 | ·015 | 10 | 2·16 | 11-12 noon | 4·2 | 11-12 noon |
| 14 | ·465 | ·16 | 60 | 3·84 | 3-5 a.m. | 5·4 | 4-5 a.m. |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | ·01 | ·01 | 15 | ·96 | 5-6 p.m. | 3·8 | 7-8 p.m. |
| 18 | — | — | — | — | — | — | — |
| 19 | ·50 | ·13 | 60 | 3·12 | 6-7 a.m. | 7·0 | 6-7 a.m. |
| 20 | ·545 | ·40 | 30 | 19·20 | 2-3 p.m. | 9·2 | 3-4 p.m. |
| 21 | ·29 | ·08 | 40 | 2·88 | 2-4 a.m. | 6·6 | 3-4 a.m. |
| 22 | — | — | — | — | — | — | — |
| 23 | ·005 | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | — | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | ·03 | ·015 | 30 | ·72 | 6-8 a.m. | 3·9 | 8-9 a.m. |
| 31 | ·18 | ·06 | 20 | 4·32 | 6-7 a.m. | 4·4 | 7-8 a.m. |

### AUGUST 1879.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | ·13 | ·09 | 15 | 8·64 | 1-2 a.m. | 4·3 | 2-3 a.m. |
| 3 | ·02 | ·015 | 10 | 2·16 | 6-7 a.m. | 3·9 | 7-8 a.m. |
| 4 | — | — | — | — | — | — | — |
| 5 | ·10 | ·05 | 35 | 2·06 | 7-9 p.m. | 4·5 | 9-10 p.m. |
| 6 | ·105 | ·05 | 20 | 3·60 | 4-5 p.m. | 6·1 | 4-5 p.m. |
| 7 | ·14 | ·045 | 60 | 1·08 | 9-10 p.m. | 3·7 | 10-11 p.m. |
| 8 | ·015 | ·005 | 5 | 1·44 | 1-2 p.m. | 3·5 | 3-4 p.m. |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | ·01 | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | ·005 | — | — | — | — | — | — |
| 16 | ·175 | ·09 | 60 | 2·16 | 7-9 a.m. | 4·2 | 8-9 a.m. |
| 17 | ·65 | ·11 | 60 | 2·64 | 9-10 a.m. | 8·6 | 10-11 a.m. |
| 18 | ·005 | — | — | — | — | — | — |
| 19 | ·75 | ·10 | 60 | 2·40 | 5-6 a.m. | 5·7 | 5-6 a.m. |
| 20 | ·05 | ·01 | 15 | ·96 | 1-2 p.m. | 4·1 | 3-4 p.m. |
| 21 | ·19 | ·08 | 20 | 5·76 | 2-3 p.m. | 5·2 | 2-3 p.m. |
| 22 | ·38 | ·11 | 5 | ·28 | 8-9 a.m. | 6·4 | 8-9 a.m. |
| 23 | ·615 | ·30 | 60 | 7·20 | 10 a.m.–12 | 8·3 | 11 a.m.–12 |
| 24 | ·015 | ·005 | 15 | ·36 | 1-2 a.m. | 3·6 | 2-3 a.m. |
| 25 | ·025 | ·02 | 5 | 5·76 | 11-12 a.m. | 3·8 | 12-1 a.m. |
| 26 | ·36 | ·20 | 60 | 4·80 | 1-3 p.m. | 5·1 | 3-4 p.m. |
| 27 | ·515 | ·10 | 60 | 2·40 | -8 a.m. | 6·3 | 8-9 a.m. |
| 28 | ·18 | ·09 | 60 | 2·16 | -10 a.m. | 6·0 | 9-10 a.m. |
| 29 | ·005 | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

### SEPTEMBER 1879.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | ·015 | ·01 | 10 | 1·44 | 4-5 p.m. | 4·5 | 5-6 p.m. |
| 8 | ·08 | ·03 | 5 | 8·64 | 10-11 a.m. | 5·2 | 11-12 a.m. |
| 9 | ·19 | ·11 | 30 | 5·28 | 1-2 p.m. | 5·3 | 2-3 p.m. |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | ·17 | ·07 | 60 | 1·68 | 9-11 p.m. | 5·2 | 10-11 p.m. |
| 13 | ·43 | ·13 | 40 | 4·68 | 4-6 p.m. | 8·0 | 5-6 p.m. |
| 14 | ·005 | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | ·025 | ·01 | 10 | 1·44 | 4-5 a.m. | 4·1 | 5-6 a.m. |
| 17 | ·04 | ·01 | 20 | ·72 | 7-8 a.m. | 4·9 | 7-8 a.m. |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | ·105 | ·07 | 60 | 1·68 | 8-9 a.m. | 4·6 | 9-10 a.m. |
| 23 | 1·34 | ·23 | 60 | 5·52 | 2-3 a.m. | 11·3 | 2-3 a.m. |
| 24 | ·075 | ·05 | 25 | 2·88 | 4-5 p.m. | 5·1 | 5-6 p.m. |
| 25 | — | — | — | — | — | — | — |
| 26 | — | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | ·425 | ·10 | 60 | 2·40 | 10 p.m.–12 | 5·9 | 11 p.m.–12 |
| 29 | ·005 | — | — | — | — | — | — |
| 30 | ·255 | ·12 | 60 | 2·88 | 4-6 a.m. | 6·3 | 6-7 a.m. |

## OCTOBER 1879.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rain-fall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | ·0175 | 00 | 60 | ·120 | 9–10 a.m. | 5·8 | 9–10 a.m. |
| 2 | ·045 | 03 | 10 | 4·32 | 12–1 p.m. | 5·5 | 12–1 p.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | ·005 | — | — | — | — | — | — |
| 10 | ·005 | — | — | — | — | — | — |
| 11 | ·005 | — | — | — | — | — | — |
| 12 | ·01 | ·005 | 60 | ·12 | 7–8 a.m. | 4·5 | 8–9 a.m. |
| 13 | ·01 | ·005 | 60 | ·12 | 6–7 a.m. | 5·9 | 6–7 a.m. |
| 14 | ·005 | ·005 | 5 | 1·44 | 9–10 p.m. | 4·6 | 9–10 p.m. |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | ·06 | ·015 | 10 | 2·16 | 12–1 a.m. | 4·2 | 1–2 a.m. |
| 19 | ·06 | ·02 | 10 | 2·88 | 6–7 p.m. | 4·4 | 7–8 p.m. |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | ·025 | ·010 | 60 | ·24 | 2–3 p.m. | 4·4 | 2–3 p.m. |
| 23 | ·025 | ·010 | 20 | ·72 | 4–5 a.m. | 4·3 | 6–7 a.m. |
| 24 | ·35 | ·16 | 60 | 3·84 | 11 p.m.–1 | 7·1 | 12–1 a.m. |
| 25 | — | — | — | — | — | — | — |
| 26 | ·005 | ·005 | 15 | ·48 | 9–10 a.m. | 4·6 | 9–10 a.m. |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | ·06 | ·01 | 60 | ·24 | 3–4 p.m. | 4·5 | 4–5 p.m. |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

## NOVEMBER 1879.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·03 | ·015 | 60 | ·36 | 10–11 p.m. | 4·2 | 11 p.m.–12 |
| 2 | — | — | — | — | — | — | — |
| 3 | ·02 | ·01 | 40 | ·36 | 10–11 a.m. | 4·8 | 11 a.m.–12 |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | ·005 | — | — | — | — | — | — |
| 11 | ·03 | ·03 | 50 | ·864 | 5–7 p.m. | 4·9 | 6–7 p.m. |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | ·005 | — | — | — | — | — | — |
| 19 | ·01 | ·005 | 60 | ·120 | 9–10 a.m. | 4·0 | 10–11 a.m. |
| 20 | ·33 | ·10 | 60 | 2·40 | 10–11 a.m. | 4·5 | 10–11 a.m. |
| 21 | ·33 | ·08 | 60 | 1·92 | 8–9 p.m. | 3·9 | 9–10 p.m. |
| 22 | ·08 | ·07 | 60 | 1·68 | 9–10 a.m. | 4·3 | 10–11 a.m. |
| 23 | — | — | — | — | — | — | — |
| 24 | ·205 | ·055 | 60 | 1·32 | 9–10 p.m. | 5·6 | 10–11 p.m. |
| 25 | ·08 | ·03 | 15 | 2·88 | 7–8 p.m. | 4·4 | 8–9 p.m. |
| 26 | — | — | — | — | — | — | — |
| 27 | ·015 | ·015 | 15 | 1·44 | 11 p.m.–12 | 3·8 | 11 p.m.–12 |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |

## DECEMBER 1879.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·05 | ·03 | 40 | 1·08 | 1–2 p.m. | 3·8 | 2–3 p.m. |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | ·07 | ·04 | 10 | 5·76 | 10–11 p.m. | 3·3 | 11–p.m.–12 |
| 6 | — | — | — | — | — | — | — |
| 7 | ·03 | ·01 | 60 | ·24 | 7–8 a.m. | 3·4 | 8–9 a.m. |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | ·02 | ·01 | 15 | ·96 | 10–11 a.m. | 4·0 | 11 a.m.–12 |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | ·01 | — | — | — | — | — | — |
| 19 | ·005 | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | ·09 | ·05 | 45 | 1·60 | 11 a.m.–12 | 4·2 | 12–1 p.m. |
| 23 | — | — | — | — | — | — | — |
| 24 | ·005 | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | ·005 | — | — | — | — | — | — |
| 27 | ·03 | ·03 | 15 | 2·88 | 4–5 a.m. | 3·5 | 7–8 a.m. |
| 28 | ·015 | ·005 | 30 | ·24 | 11 a.m.–12 | 3·3 | 11 a.m.–12 |
| 29 | ·10 | ·10 | 20 | 7·20 | 5–6 p.m. | 3·6 | 6–7 p.m. |
| 30 | ·30 | ·12 | 30 | 5·76 | 12–1 p.m. | 5·7 | 1–2 p.m. |
| 31 | ·20 | ·05 | 60 | 1·20 | 4–5 p.m. | 4·0 | 5–6 p.m. |

## JANUARY 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | ·01 | ·01 | 10 | 1·44 | 9–10 a.m. | 2·97 | 10–11 a.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | ·01 | — | — | — | — | — | — |
| 10 | ·005 | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | ·05 | ·025 | 50 | ·72 | 7–8 p.m. | 3·3 | 7–8 p.m. |
| 14 | — | — | — | — | — | — | — |
| 15 | ·085 | ·05 | 45 | 1·60 | 9–11 p.m. | 3·1 | 10–11 p.m. |
| 16 | ·235 | ·045 | 60 | 1·08 | 10–11 a.m. | 4·1 | 11 a.m.–12 |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | ·005 | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | — | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | ·005 | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

## FEBRUARY 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | ·005 | — | — | — | — | — | — |
| 6 | ·13 | ·03 | 30 | 1·44 | 1–3 a.m. | 2·1 | 3–4 a.m. |
| 7 | ·515 | ·09 | 60 | 2·16 | 3–5 a.m. | 4·4 | 4–5 a.m. |
| 8 | ·14 | ·12 | 60 | 2·88 | 7–8 a.m. | 5·2 | 8–9 a.m. |
| 9 | ·17 | ·075 | 60 | 1·80 | 3–4 p.m. | 3·2 | 4–5 p.m. |
| 10 | — | — | — | — | — | — | — |
| 11 | ·035 | ·03 | 25 | 1·728 | 8–9 a.m. | 2·1 | 8–9 a.m. |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | ·145 | ·06 | 60 | 1·44 | 11 a.m.–1 | 2·9 | 2–3 p.m. |
| 15 | ·255 | ·085 | 60 | 2·04 | 8–9 p.m. | 4·0 | 9–10 a.m. |
| 16 | ·54 | ·22 | 60 | 5·28 | 9–11 a.m. | 6·7 | 10–11 a.m. |
| 17 | ·11 | ·07 | 60 | 2·016 | 7–9 a.m. | 4·4 | 8–9 a.m. |
| 18 | ·20 | ·08 | 60 | 1·92 | 8–9 p.m. | 4·5 | 9–10 p.m |
| 19 | ·075 | ·015 | 45 | ·48 | 3–4 a.m. | 2·4 | 4–5 a.m. |
| 20 | ·03 | ·015 | 5 | 4·32 | 2–3 p.m. | 2·9 | 3–4 p.m. |
| 21 | ·08 | ·06 | 20 | 4·32 | 4–5 p.m. | 3·8 | 5–6 p.m. |
| 22 | ·015 | ·005 | 45 | ·160 | 2–3 p.m. | — | — |
| 23 | ·095 | ·03 | 60 | ·72 | 6–7 p.m. | 2·9 | 7–8 p.m. |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | ·005 | — | — | — | — | — | — |
| 27 | ·015 | ·015 | 45 | ·48 | 7–8 a.m. | 2·9 | 7–8 a.m. |
| 28 | — | — | — | — | — | — | — |
| 29 | ·05 | ·04 | 20 | 2·88 | 8–9 a.m. | 2·8 | 8–9 a.m. |

## MARCH 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·065 | ·035 | 5 | 10·08 | 3–4 p.m. | 2·5 | 4–5 p.m. |
| 2 | ·12 | ·06 | 40 | 2·16 | 1–3 a.m. | 3·3 | 3–4 a.m. |
| 3 | ·01 | ·005 | 15 | ·48 | 10–11 p.m. | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | ·05 | ·015 | 40 | ·54 | 2–3 p.m. | 2·5 | 3–4 p.m. |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | — | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | ·395 | ·08 | 60 | 1·92 | 7–9 p.m. | 3·7 | 8–9 p.m. |

## APRIL 1880.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rain-fall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | ·055 | ·04 | 60 | ·96 | 8–9 a.m. | 2·4 | 8–9 a.m. |
| 2 | ·225 | ·06 | 30 | 2·88 | 12–2 p.m. | 3·7 | 1–2 p.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | ·16 | ·04 | 10 | 5·76 | 3–4 p.m. | 3·0 | 4–5 p.m. |
| 6 | ·035 | ·03 | 45 | ·96 | 5–7 p.m. | 2·3 | 7–8 p.m. |
| 7 | — | — | — | — | — | — | — |
| 8 | ·04 | ·035 | 5 | 10·08 | 1–2 p.m. | 2·4 | 2–3 p.m. |
| 9 | — | — | — | — | — | — | — |
| 10 | ·01 | ·005 | 60 | ·12 | 5–6 a.m. | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | ·01 | — | — | — | — | — | — |
| 13 | ·115 | ·035 | 60 | ·84 | 7–9 a.m. | 2·4 | 8–9 a.m. |
| 14 | ·65 | ·20 | 60 | 4·80 | 2–3 p.m. | 7·9 | 3–4 p.m. |
| 15 | ·19 | ·04 | 10 | 5·76 | 3–4 p.m. | 4·5 | 3–4 p.m. |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | ·27 | ·12 | 60 | 2·88 | 3–4 a.m. | 4·0 | 5–6 a.m. |
| 20 | — | — | — | — | — | — | — |
| 21 | ·03 | ·015 | 60 | ·36 | 2–3 a.m. | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | 0·95 | ·07 | 15 | 6·72 | 12–1 p.m. | 2·7 | 1–2 p.m. |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |

## MAY 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | ·04 | ·02 | 60 | ·48 | 5–6 a.m. | 2·1 | 6–7 a.m. |
| 5 | ·10 | ·045 | 30 | 2·16 | 11 p.m.–12 | 2·6 | 1–2 a.m. |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | — | — | — | — | — | — | — |
| 27 | ·015 | ·01 | 10 | 1·44 | 5–6 p.m. | 2·2 | 5–6 p.m. |
| 28 | ·015 | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | ·20 | ·045 | 60 | 1·08 | 1–2 p.m. | 3·0 | 3–4 p.m. |

## JUNE 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·085 | ·04 | 10 | 5·76 | 1–2 p.m. | 2·8 | 2–3 p.m. |
| 2 | ·025 | ·025 | 5 | 7·20 | 9–10 a.m. | 2·5 | 10–11 a.m. |
| 3 | ·075 | ·03 | 60 | ·72 | 12–1 a.m. | 2·3 | 1–2 a.m. |
| 4 | — | — | — | — | — | — | — |
| 5 | ·12 | ·06 | 60 | 1·44 | 6–8 a.m. | 2·8 | 8–9 a.m. |
| 6 | ·06 | ·04 | 60 | ·96 | 9–10 a.m. | 2·9 | 10–11 a.m. |
| 7 | ·015 | ·005 | 5 | 1·44 | 9–10 p.m. | — | — |
| 8 | ·03 | ·02 | 5 | 5·76 | 9–10 a.m. | 2·6 | 10–11 a.m. |
| 9 | ·06 | ·015 | 60 | ·36 | 4–5 p.m. | 2·4 | 4–5 p.m. |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | ·075 | ·07 | 60 | 1·68 | 6–8 p.m. | 2·3 | 8–9 p.m. |
| 15 | ·64 | ·15 | 60 | 3·60 | 5–6 a.m. | 6·7 | 5–6 a.m. |
| 16 | ·435 | ·09 | 60 | 2·16 | 12–1 p.m. | 5·0 | 1–2 p.m. |
| 17 | ·54 | ·24 | 60 | 5·76 | 12–1 p.m. | 4·6 | 12–1 p.m. |
| 18 | ·035 | ·03 | 60 | ·72 | 8–9 a.m. | 3·1 | 8–9 a.m. |
| 19 | ·10 | ·045 | 60 | 1·08 | 4–6 a.m. | 2·1 | 5–6 a.m. |
| 20 | — | — | — | — | — | — | — |
| 21 | ·375 | ·26 | 40 | 9·36 | 2–3 a.m. | 8·[illegible] | 3–4 a.m. |
| 22 | ·295 | ·13 | 60 | 3·12 | 9–10 a.m. | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | ·225 | ·07 | 30 | 3·36 | 6–7 p.m. | 5·3 | 8–9 p.m. |
| 25 | — | — | — | — | — | — | — |
| 26 | ·23 | ·12 | 45 | 3·84 | 3–5 p.m. | 5·0 | 4–5 p.m. |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | ·14 | ·10 | 60 | 2·40 | 8–9 a.m. | 2·4 | 8–9 a.m. |

## JULY 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·10 | ·055 | 5 | 15·84 | 2–3 p.m. | 3·3 | 2–3 p.m. |
| 2 | ·17 | ·06 | 20 | 4·32 | 4–5 a.m. | 2·3 | 5–6 a.m. |
| 3 | ·135 | ·04 | 10 | 5·76 | 11 a.m.–12 | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | ·02 | ·01 | 60 | ·24 | 10–11 p.m. | — | — |
| 7 | ·175 | ·08 | 20 | 5·76 | 3–4 p.m. | 3·3 | 4–5 p.m. |
| 8 | ·055 | ·03 | 10 | 4·32 | 2–3 p.m. | 2·3 | 3–4 p.m. |
| 9 | ·045 | ·03 | 15 | 2·88 | 9–10 a.m. | 3·1 | 10–11 a.m. |
| 10 | ·35 | ·13 | 5 | 37·44 | 7–8 p.m. | 3·3 | 8–9 p.m. |
| 11 | ·095 | ·05 | 60 | 1·20 | 2–3 p.m. | 5·4 | 3–4 p.m. |
| 12 | — | — | — | — | — | — | — |
| 13 | ·075 | ·04 | 40 | 1·44 | 4–5 a.m. | 2·3 | 5–6 a.m. |
| 14 | ·025 | ·015 | 45 | ·48 | 5–7 a.m. | 4·8 | 8–9 a.m. |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | ·02 | ·015 | 60 | ·360 | 10–11 p.m. | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | ·015 | ·005 | 60 | ·12 | 8–9 a.m. | 1·8 | 8–9 a.m. |
| 22 | — | — | — | — | — | — | — |
| 23 | ·02 | ·02 | 20 | 1·44 | 1–2 a.m. | 1·7 | 2–3 a.m. |
| 24 | — | — | — | — | — | — | — |
| 25 | ·265 | ·08 | 40 | 2·88 | 6–7 a.m. | 2·5 | 7–8 a.m. |
| 26 | ·345 | ·06 | 30 | 2·88 | 8–9 p.m. | 3·8 | 9–10 p.m. |
| 27 | ·02 | ·010 | 10 | 1·44 | 4–5 a.m. | 1·6 | 5–6 a.m. |
| 28 | ·155 | ·05 | 45 | 1·60 | 11 p.m.–12 | 2·5 | 12–1 a.m. |
| 29 | ·78 | ·32 | 60 | 7·68 | 7–8 a.m. | 4·4 | 8–9 a.m. |
| 30 | ·02 | ·015 | 45 | ·48 | 4–5 p.m. | 2·1 | 5–6 p.m. |
| 31 | ·10 | ·02 | 60 | ·48 | 8–9 a.m. | 2·2 | 8–9 a.m. |

## AUGUST 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·01 | ·01 | 60 | ·24 | 9–10 a.m. | 2·1 | 9–10 a.m |
| 2 | ·045 | ·015 | 60 | ·36 | 6–7 p.m. | 2·1 | 7–8 p.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | ·02 | ·015 | 30 | ·72 | 3–4 p.m. | 2·4 | 3–4 p.m. |
| 7 | ·34 | ·08 | 10 | 11·52 | 10–11 p.m. | 3·2 | 10–11 p.m. |
| 8 | ·015 | ·005 | 60 | ·12 | 2–3 p.m. | 1·8 | 4–5 p.m. |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | ·005 | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | ·01 | ·005 | 60 | ·12 | 4–5 a.m. | 1·8 | 6–7 a.m. |
| 26 | — | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

## SEPTEMBER 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | ·14 | ·045 | 60 | 1·08 | 12–1 a.m. | 1·7 | 1–2 a.m. |
| 7 | — | — | — | — | — | — | — |
| 8 | ·01 | ·005 | 60 | ·12 | 3–4 a.m. | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | ·02 | ·01 | 5 | 2·88 | 1–2 a.m. | — | — |
| 11 | 1·37 | ·30 | 60 | 7·20 | 9–11 p.m. | 5·8 | 11–12 p.m. |
| 12 | ·445 | ·19 | 60 | 4·56 | 1–2 a.m. | 5·7 | 2–3 a.m. |
| 13 | ·02 | ·02 | 5 | 5·76 | 12–1 p.m. | 1·5 | 1–2 p.m. |
| 14 | 1·27 | ·27 | 60 | 6·48 | 10–11 p.m. | 7·1 | 12–1 a.m. |
| 15 | ·325 | ·20 | 20 | 14·40 | 4–5 a.m. | 8·0 | 4–5 a.m. |
| 16 | ·05 | ·035 | 10 | 5·04 | 11 a.m.–12 | 2·3 | 12–1 p.m. |
| 17 | ·06 | ·04 | 20 | 2·88 | 7–8 a.m. | 2·3 | 8–9 a.m. |
| 18 | ·61 | ·30 | 60 | 7·20 | 10–11 a.m. | 7·7 | 11 a.m.–12 |
| 19 | ·225 | ·12 | 60 | 2·88 | 10–11 a.m. | 5·7 | 11 a.m.–12 |
| 20 | ·02 | ·005 | 10 | ·72 | 6–7 a.m. | 1·7 | 8–9 a.m. |
| 21 | ·06 | ·025 | 60 | ·60 | 10–11 a.m. | 2·3 | 12–1 p.m. |
| 22 | ·02 | ·01 | 15 | ·96 | 7–8 a.m. | 1·8 | 8–9 a.m. |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | — | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |

## OCTOBER 1880.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | ·315 | ·10 | 10 | 14·40 | 3–4 p.m. | 5·4 | 4–5 p.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | ·4 | ·16 | 15 | 15·36 | 2–4 a.m. | 3·0 | 3–4 a.m. |
| 5 | ·325 | ·13 | 60 | 3·12 | 3–4 p.m. | 5·8 | 4–5 p.m. |
| 6 | ·71 | ·18 | 60 | 4·32 | 7–8 p.m. | 8·0 | 8–9 p.m. |
| 7 | ·27 | ·22 | 15 | 21·12 | 12–1 a.m. | 2·6 | 12–1 a.m. |
| 8 | ·19 | ·06 | 60 | 1·44 | 3–4 a.m. | 3·6 | 5–6 a.m. |
| 9 | 2·12 | ·45 | 60 | 10·80 | 1–3 a.m. | 6·3 | 2–3 a.m. |
| 10 | ·02 | ·005 | 5 | 1·44 | 12–1 p.m. | 4·1 | 12–1 p.m. |
| 11 | ·015 | — | — | — | — | — | — |
| 12 | ·10 | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | ·02 | ·005 | 60 | ·120 | 7–8 a.m. | — | — |
| 19 | ·49 | ·065 | 60 | 1·56 | 2–3 a.m. | 4·4 | 2–3 a.m. |
| 20 | ·21 | ·16 | 60 | 3·84 | 11 a.m.–12 | 3·84 | 1–2 p.m. |
| 21 | ·11 | ·06 | 50 | 1·728 | 5–6 a.m. | 3·8 | 6–7 a.m. |
| 22 | ·49 | ·04 | 15 | 3·84 | 11 p.m.–12 | 5·4 | 12–1 a.m. |
| 23 | ·015 | ·005 | 60 | ·12 | 1–2 a.m. | — | — |
| 24 | ·005 | — | — | — | — | — | — |
| 25 | ·04 | ·04 | 60 | ·96 | 8–9 a.m. | 3·7 | 9–10 a.m. |
| 26 | ·95 | ·22 | 60 | 5·28 | 2–3 a.m. | 9·5 | 2–3 a.m. |
| 27 | ·27 | ·04 | 10 | 5·76 | 9–10 p.m. | 4·2 | 10–11 p.m. |
| 28 | ·43 | ·16 | 30 | 7·68 | 10–11 a.m. | 9·2 | 11–12 noon |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | ·005 | — | — | — | — | — | — |

## NOVEMBER 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | ·005 | ·005 | 60 | ·12 | 3–4 p.m. | 2·8 | 4–5 p.m. |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | ·105 | ·055 | 60 | 1·32 | 3–4 a.m. | 3·3 | 4–5 a.m. |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | ·085 | ·04 | 15 | 3·84 | 7–8 a.m. | 3·8 | 8–9 a.m. |
| 12 | ·02 | ·01 | 15 | ·96 | 7–8 a.m. | 2·5 | 8–9 a.m. |
| 13 | ·06 | ·025 | 60 | ·60 | 8–9 a.m. | 2·9 | 10–11 a.m. |
| 14 | ·30 | ·06 | 60 | 1·44 | 10 a.m.–12 | 4·1 | 12–1 p.m. |
| 15 | ·44 | ·12 | 60 | 2·88 | 3–4 p.m. | 6·1 | 3–4 p.m. |
| 16 | ·085 | ·06 | 10 | 8·64 | 11 a.m.–12 | 4·2 | 12–1 p.m. |
| 17 | — | — | — | — | — | — | — |
| 18 | ·585 | ·04 | 40 | 1·44 | 7–8 p.m. | 5·0 | 8–9 p.m. |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | ·01 | ·005 | 60 | ·12 | 5–6 p.m. | — | — |
| 24 | ·265 | ·04 | 10 | 5·76 | 11 p.m.–12 | 3·6 | 12–1 a.m. |
| 25 | ·23 | ·05 | 20 | 3·60 | 4–5 a.m. | 3·8 | 5–6 a.m. |
| 26 | ·13 | ·05 | 50 | 1·44 | 11 a.m.–12 | 4·5 | 12–1 p.m. |
| 27 | — | — | — | — | — | — | — |
| 28 | ·005 | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |

## DECEMBER 1880.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·065 | ·05 | 20 | 3·60 | 11 p.m.–12 | 6·0 | 12–1 a.m. |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | ·05 | ·025 | 5 | 7·20 | 6–7 a.m. | 2·7 | 7–8 a.m. |
| 14 | ·25 | ·045 | 60 | 1·08 | 3–5 p.m. | 3·7 | 5–6 p.m. |
| 15 | ·085 | ·06 | 60 | 1·44 | 12–2 p.m. | 4·2 | 2–3 p.m. |
| 16 | ·12 | ·06 | 40 | 2·16 | 10–11 a.m. | 4·9 | 11 a.m.–12 |
| 17 | ·01 | — | — | — | — | — | — |
| 18 | ·04 | ·025 | 60 | ·60 | 3–5 p.m. | 1·8 | 4–5 p.m. |
| 19 | ·555 | ·215 | 60 | 5·16 | 3–4 a.m. | 5·9 | 4–5 a.m. |
| 20 | ·35 | ·165 | 60 | 3·96 | 1–3 p.m. | 7·0 | 2–3 p.m. |
| 21 | ·115 | ·05 | 60 | 1·20 | 7–8 a.m. | 4·5 | 8–9 a.m. |
| 22 | ·27 | ·115 | 60 | 2·76 | 10 a.m.–12 | 6·4 | 12–1 p.m. |
| 23 | ·03 | ·02 | 20 | 1·44 | 4–6 a.m. | 3·0 | 6–7 a.m. |
| 24 | ·02 | ·02 | 20 | 1·44 | 9–10 a.m. | 4·5 | 9–10 a.m. |
| 25 | — | — | — | — | — | — | — |
| 26 | ·10 | ·04 | 60 | ·96 | 1–2 a.m. | 3·9 | 3–4 a.m. |
| 27 | ·135 | ·035 | 15 | 3·36 | 7–8 p.m. | 4·8 | 8–9 p.m. |
| 28 | — | — | — | — | — | — | — |
| 29 | ·77 | ·23 | 10 | 33·12 | 7–8 p.m. | 7·3 | 9–10 p.m. |
| 30 | ·09 | ·08 | 60 | 1·92 | 3–5 a.m. | — | — |
| 31 | — | — | — | — | — | — | — |

## JANUARY 1881.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | ·005 | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | ·01 | ·01 | 5 | 2·88 | 9–10 p.m. | — | — |
| 11 | ·07 | ·04 | 60 | ·96 | 8–9 a.m. | 4·5 | 9–10 (12th) a.m. |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | ·40 | ·10 | 60 | 2·40 | 3–5 a.m. | 3·5 | 4–5 a.m. |
| 19 | ·05 | ·01 | 60 | ·24 | 3–4 p.m. | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | ·08 | ·02 | 15 | 1·92 | 5–6 a.m. | 3·6 | 6–7 a.m. |
| 27 | ·07 | ·03 | 60 | ·72 | 8–9 a.m. | 4·5 | 9–10 (28th) a.m. |
| 28 | ·095 | ·02 | 60 | ·48 | 1–3 a.m. | 4·1 | 3–4 a.m. |
| 29 | ·255 | ·05 | 20 | 3·60 | 1–3 p.m. | 6·0 | 3–4 p.m. |
| 30 | ·085 | ·03 | 15 | 2·88 | 4–5 p.m. | 4·6 | 5–6 p.m. |
| 31 | ·01 | — | — | — | — | — | — |

## FEBRUARY 1881.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·015 | ·005 | 5 | 1·44 | 6–7 a.m. | 3·6 | 8–9 a.m. |
| 2 | ·165 | ·04 | 10 | 5·76 | 2–3 p.m. | 4·8 | 3–4 p.m. |
| 3 | ·07 | ·03 | 20 | 2·16 | 1–2 p.m. | 4·0 | 2–3 p.m. |
| 4 | ·025 | ·01 | 20 | ·72 | 1–2 a.m. | — | — |
| 5 | ·005 | ·005 | 60 | ·120 | 10–11 p.m. | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | ·53 | ·15 | 15 | 14·40 | 9–10 p.m. | 8·5 | 9–11 p.m. |
| 8 | — | — | — | — | — | — | — |
| 9 | ·30 | ·04 | 60 | ·96 | 6–7 a.m. | 4·9 | 6–7 a.m. |
| 10 | ·26 | ·06 | 5 | 17·28 | 11 a.m.–12 | 5·6 | 12–1 p.m. |
| 11 | ·01 | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | ·325 | ·055 | 60 | 1·32 | 7–9 a.m. | 6·0 | 8–9 a.m. |
| 15 | ·095 | ·045 | 60 | 1·08 | 10–11 a.m. | 6·2 | 11 a.m.–12 |
| 16 | ·005 | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | ·01 | ·005 | 60 | ·120 | 3–4 a.m. | — | — |
| 19 | ·475 | ·10 | 60 | 2·40 | 3–5 a.m. | 7·8 | 4–5 a.m. |
| 20 | ·24 | ·10 | 60 | 2·40 | 1–3 a.m. | 6·1 | 2–3 a.m. |
| 21 | — | — | — | — | — | — | — |
| 22 | ·005 | — | — | — | — | — | — |
| 23 | ·495 | ·05 | 45 | 1·60 | 7–9 p.m. | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | ·01 | — | — | — | — | — | — |
| 27 | ·01 | ·01 | 5 | 2·88 | 9–10 a.m. | 5·7 | 10–11 a.m. |
| 28 | — | — | — | — | — | — | — |

## MARCH 1881.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | ·075 | ·025 | 30 | 1·20 | 8–9 a.m. | 6·3 | 8–9 a.m. |
| 4 | ·275 | ·07 | 50 | 2·016 | 4–6 a.m. | 7·1 | 5–6 a.m. |
| 5 | ·51 | ·14 | 40 | 5·04 | 11 p.m.–12 | 12·4 | 11 p.m.– 2 |
| 6 | ·075 | ·02 | 30 | ·96 | 5–6 a.m. | 5·6 | 6–7 a.m. |
| 7 | ·08 | ·04 | 20 | 2·88 | 7–8 a.m. | 6·2 | 8–9 a.m. |
| 8 | ·07 | ·03 | 60 | ·72 | 6–7 a.m. | 5·6 | 7–8 a.m. |
| 9 | ·01 | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | ·13 | ·06 | 15 | 5·76 | 7–3 p.m. | 6·2 | 8–9 p.m. |
| 21 | ·035 | ·02 | 20 | 1·44 | 6–7 p.m. | 5·3 | 6–7 p.m. |
| 22 | ·05 | ·03 | 60 | ·72 | 11 a.m.–12 | 5·7 | 12–1 p.m. |
| 23 | ·175 | ·065 | 60 | 1·56 | 2–3 a.m. | 6·0 | 3–4 a.m. |
| 24 | ·06 | ·025 | 10 | 3·60 | 1–2 a.m. | 5·5 | 2–3 a.m. |
| 25 | — | — | — | — | — | — | — |
| 26 | ·005 | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

## APRIL 1881.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | ·095 | ·035 | 60 | ·84 | 7–8 a.m. | 5·1 | 8–9 a.m. |
| 12 | ·025 | ·025 | 60 | ·60 | 9–10 a.m. | 5·7 | 9–10 a.m. |
| 13 | ·01 | ·01 | 5 | 2·88 | 9–10 p.m. | 4·3 | 10–11 p.m. |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | ·005 | ·005 | 60 | ·120 | 8–9 p.m. | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | ·005 | ·005 | 30 | ·240 | 4–5 p.m. | 4·6 | 5–6 p.m. |
| 23 | ·15 | ·06 | 60 | 1·44 | 9–10 p.m. | 4·9 | 10–11 p.m. |
| 24 | — | — | — | — | — | — | — |
| 25 | ·005 | ·005 | 10 | ·72 | 6–7 a.m. | 4·4 | 7–8 a.m. |
| 26 | ·05 | ·025 | 5 | 7·20 | 12–1 p.m. | 4·7 | 2–3 p.m. |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | ·065 | ·04 | 10 | 5·76 | 9–10 p.m. | 4·0 | 11 p.m.–12 |
| 30 | ·085 | ·085 | 30 | 4·08 | 6–7 p.m. | 5·1 | 7–8 p.m. |

## MAY 1881.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | ·065 | ·03 | 60 | ·72 | 7–8 p.m. | 4·6 | 7–8 p.m. |
| 2 | ·15 | ·125 | 20 | 9·00 | 6–7 p.m. | 5·8 | 7–8 p.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | ·02 | ·015 | 45 | ·48 | 3–5 p.m. | 4·0 | 5–6 p.m. |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | ·015 | ·015 | 5 | 4·32 | 6–7 p.m. | 3·6 | 7–8 p.m. |
| 16 | ·02 | ·01 | 5 | 2·88 | 1–2 p.m. | 3·6 | 2–3 p.m. |
| 17 | ·08 | ·02 | 60 | ·48 | 8–9 p.m. | 3·3 | 9–10 p.m. |
| 18 | ·185 | ·045 | 60 | 1·08 | 4–5 p.m. | 3·9 | 5–6 p.m. |
| 19 | — | — | — | — | — | — | — |
| 20 | ·09 | ·06 | 20 | 4·32 | 2–3 p.m. | 4·2 | 3–4 p.m. |
| 21 | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | ·05 | ·025 | 10 | 3·60 | 4–5 p.m. | 4·9 | 4–5 p.m. |
| 26 | ·005 | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | ·22 | ·065 | 30 | 3·12 | 7–9 a.m. | 4·2 | 9–10 (29th) a.m. |
| 29 | ·02 | ·02 | 10 | 2·88 | 1–2 p.m. | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

## JUNE 1881.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | ·61 | ·08 | 60 | 1·92 | 4–5 p.m. | 4·8 | 5–6 p.m. |
| 6 | ·24 | ·105 | 45 | 3·36 | 8–9 p.m. | 4·4 | 9–10 p.m. |
| 7 | ·115 | ·055 | 30 | 2·64 | 2–3 p.m. | 4·2 | 3–4 p.m. |
| 8 | ·005 | ·005 | 60 | ·120 | 3–4 p.m. | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | ·015 | ·005 | 60 | ·120 | 2–3 p.m. | 2·4 | 3–4 p.m. |
| 17 | ·53 | ·285 | 60 | 6·84 | 7–9 p.m. | 5·2 | 8–9 p.m. |
| 18 | ·01 | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | ·02 | ·01 | 60 | ·24 | 1–2 p.m. | 2·3 | 3–4 p.m. |
| 21 | ·06 | ·015 | 5 | 4·32 | 7–8 p.m. | 2·4 | 8–9 p.m. |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | ·105 | ·08 | 60 | 1·92 | 11 a.m.–12 | 3·4 | 12–1 p.m. |
| 26 | — | — | — | — | — | — | — |
| 27 | ·01 | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |

## JULY 1881.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | ·575 | ·20 | 20 | 14·4 | 2–3 a.m. | 5·0 | 3–4 a.m. |
| 6 | ·16 | ·16 | 15 | 15·36 | 10–11 a.m. | 7·2 | 11 a.m.–12 |
| 7 | — | — | — | — | — | — | — |
| 8 | ·02 | ·01 | 60 | ·24 | 7–8 p.m. | 2·0 | 8–9 p.m. |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | ·01 | ·01 | 15 | ·96 | 10–11 a.m. | 2·4 | 11 a.m.–12 |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | ·03 | ·015 | 5 | 4·32 | 5–6 a.m. | 2·0 | 6–7 a.m. |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | ·01 | ·01 | 60 | ·24 | 6–7 a.m. | 1·9 | 7–8 a.m. |
| 20 | ·01 | ·005 | 10 | ·72 | 9–10 a.m. | 2·4 | 10–11 a.m. |
| 21 | ·055 | ·055 | 30 | 2·64 | 8–9 a.m. | 2·7 | 9–10 (22nd) a.m. |
| 22 | ·055 | ·04 | 20 | 2·88 | 12–1 p.m. | 2·8 | 1–2 p.m. |
| 23 | ·035 | ·015 | 60 | ·36 | 10–11 p.m. | 3·9 | 11 p.m.–12 |
| 24 | ·08 | ·015 | 5 | 4·32 | 12–1 p.m. | 2·6 | 1–2 p.m. |
| 25 | — | — | — | — | — | — | — |
| 26 | ·02 | ·015 | 5 | 4·32 | 5–6 p.m. | 2·2 | 6–7 p.m. |
| 27 | ·01 | ·01 | 30 | ·48 | 4–5 p.m. | 2·0 | 5–6 p.m. |
| 28 | ·175 | ·075 | 30 | 3·60 | 1–2 a.m. | 2·7 | 2–3 a.m. |
| 29 | — | — | — | — | — | — | — |
| 30 | ·225 | ·075 | 20 | 5·40 | 10 a.m.–12 | 3·3 | 11 a.m.–12 |
| 31 | ·365 | ·20 | 60 | 4·80 | 9–10 a.m. | 6·4 | 10–11 a.m. |

## AUGUST 1881.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | 0·5 | 0·2 | 30 | 9·6 | 8–9 p.m. | 2·2 | 8–9 p.m. |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | ·395 | ·20 | 60 | 4·8 | 8–9 p.m. | 6·1 | 8–9 p.m. |
| 9 | — | — | — | — | — | — | — |
| 10 | ·015 | ·005 | 60 | ·12 | 5–6 p.m. | — | — |
| 11 | ·20 | ·045 | 60 | 1·08 | 12–1 a.m. | 2·2 | 1–2 a.m. |
| 12 | 1·23 | ·60 | 10 | 86·4 | 5–6 p.m. | 7·0 | 6–7 p.m. |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | ·03 | ·01 | 15 | ·96 | 4–5 a.m. | 2·0 | 5–6 a.m. |
| 16 | ·05 | ·025 | 30 | 1·20 | 1–2 a.m. | 2·0 | 2–3 a.m. |
| 17 | ·265 | ·09 | 30 | 4·32 | 6–7 p.m. | 3·9 | 8–9 p.m. |
| 18 | ·03 | ·015 | 30 | ·72 | 5–6 a.m. | 1·9 | 6–7 a.m. |
| 19 | ·03 | ·01 | 60 | ·24 | 5–6 p.m. | — | — |
| 20 | ·015 | ·01 | 30 | ·48 | 2–3 a.m. | — | — |
| 21 | ·405 | ·175 | 30 | 8·40 | 1–3 p.m. | 8·0 | 4–5 p.m. |
| 22 | ·03 | ·01 | 5 | 2·88 | 2–3 p.m. | 2·4 | 3–4 p.m. |
| 23 | ·195 | ·065 | 20 | 4·68 | 4–5 p.m. | 4·0 | 6–7 p.m. |
| 24 | ·07 | ·02 | 45 | ·64 | 7–8 a.m. | 2·6 | 8–9 a.m. |
| 25 | ·51 | ·15 | 60 | ·60 | 2–4 p.m. | 5·2 | 4–5 p.m. |
| 26 | ·14 | ·06 | 5 | 17·28 | 6–7 p.m. | 4·0 | 7–8 p.m. |
| 27 | — | — | — | — | — | — | — |
| 28 | ·02 | ·01 | 60 | ·24 | 8–9 a.m. | 3·5 | 9–10 (29th) a.m. |
| 29 | ·32 | ·115 | 40 | 4·14 | 7–8 p.m. | 5·3 | 8–9 p.m. |
| 30 | ·01 | ·005 | 60 | ·12 | 5–6 p.m. | 2·4 | 5–6 p.m. |
| 31 | ·005 | ·005 | 30 | ·24 | 6–7 p.m. | — | — |

## SEPTEMBER 1881.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | ·005 | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | ·01 | ·01 | 20 | ·72 | 7–8 a.m. | 3·6 | 9–10 (5th) a.m. |
| 5 | ·345 | ·18 | 60 | 4·32 | 11 p.m.–12 | 6·4 | 12–1 a.m. |
| 6 | ·04 | ·02 | 10 | 2·88 | 8–9 p.m. | 2·0 | 10–11 p.m. |
| 7 | ·01 | ·005 | 5 | 1·44 | 1–2 p.m. | 2·8 | 4–5 p.m. |
| 8 | ·04 | ·01 | 60 | ·24 | 10–11 p.m. | 1·8 | 11 p.m.–12 |
| 9 | — | — | — | — | — | — | — |
| 10 | ·085 | ·04 | 20 | 2·88 | 5–6 p.m. | 2·5 | 6–7 p.m. |
| 11 | ·10 | ·045 | 60 | 1·08 | 10–11 a.m. | 2·7 | 11 a.m.–12 |
| 12 | ·01 | ·005 | 30 | ·24 | 2–3 p.m. | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | ·02 | ·005 | 5 | 1·44 | 9–10 a.m. | 1·9 | 10–11 a.m. |
| 16 | — | — | — | — | — | — | — |
| 17 | ·08 | ·045 | 30 | 2·16 | 4–6 a.m. | 2·4 | 5–6 a.m. |
| 18 | ·05 | ·02 | 20 | 1·44 | 11 p.m.–12 | 1·8 | 12–1 a.m. |
| 19 | ·025 | ·025 | 10 | 3·60 | 10–11 a.m. | 2·7 | 11 a.m.–12 |
| 20 | ·27 | ·10 | 5 | 28·8 | 1–2 a.m. | 5·9 | 2–3 a.m. |
| 21 | ·035 | ·03 | 10 | 4·32 | 9–10 a.m. | 2·8 | 10–11 a.m. |
| 22 | ·28 | ·12 | 60 | 2·88 | 7–9 p.m. | 4·7 | 8–9 p.m. |
| 23 | ·01 | — | — | — | — | — | — |
| 24 | ·50 | ·165 | 60 | 3·96 | 7–9 p.m. | 6·3 | 8–9 p.m. |
| 25 | — | — | — | — | — | — | — |
| 26 | ·145 | ·075 | 5 | 21·6 | 10–11 a.m. | 4·2 | 11 a.m.–12 |
| 27 | ·005 | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |

## OCTOBER 1881.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rain-fall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | ·01 | — | — | — | — | — | — |
| 4 | ·02 | ·015 | 5 | 4·32 | 10–11 a.m. | 2·1 | 11 a.m.–12 |
| 5 | ·02 | ·005 | 15 | ·48 | 2–3 p.m. | — | — |
| 6 | ·04 | ·02 | 30 | ·96 | 10–11 a.m. | 2·3 | 11 a.m.–12 |
| 7 | ·23 | ·075 | 60 | 1·80 | 4–5 a.m. | 3·6 | 5–6 a.m. |
| 8 | ·41 | ·09 | 60 | 2·16 | 10 a.m.–12 | 4·5 | 12–1 p.m. |
| 9 | ·015 | ·005 | 5 | 1·44 | 7–8 p.m. | — | — |
| 10 | ·01 | — | — | — | — | — | — |
| 11 | ·005 | ·005 | 60 | ·12 | 1–2 p.m. | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | ·30 | ·095 | 60 | 2·28 | 8–9 p.m. | 5·1 | 8–9 p.m. |
| 14 | — | — | — | — | — | — | — |
| 15 | ·03 | ·03 | 10 | 4·32 | 12–1 p.m. | 2·5 | 1–2 p.m. |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | ·19 | ·075 | 60 | 1·80 | 5–7 a.m. | 3·1 | 6–7 a.m. |
| 21 | ·005 | ·005 | 5 | 1·44 | 9–10 a.m. | 2·9 | 9–10 a.m. |
| 22 | 1·10 | ·12 | 5 | 34·56 | 1–2 a.m. | 6·6 | 4–5 a.m. |
| 23 | ·015 | ·015 | 20 | 1·08 | 9–10 a.m. | 4·0 | 10–11 a.m. |
| 24 | — | — | — | — | — | — | — |
| 25 | ·01 | — | — | — | — | — | — |
| 26 | ·03 | ·01 | 30 | ·48 | 7–8 a.m. | 1·8 | 8–9 a.m. |
| 27 | ·005 | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | ·005 | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | ·005 | ·005 | 10 | ·72 | 11 a.m.–12 | 1·9 | 12–1 p.m. |

## NOVEMBER 1881.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·02 | ·01 | 15 | ·96 | 2–3 p.m. | — | — |
| 2 | ·06 | ·05 | 60 | 1·20 | 6–7 a.m. | 1·4 | 6–7 a.m. |
| 3 | ·13 | ·08 | 10 | 11·52 | 8–9 a.m. | 3·0 | 9–10 (4th) a.m. |
| 4 | ·01 | — | — | — | — | — | — |
| 5 | ·255 | ·06 | 5 | 17·28 | 3–4 a.m. | 4·1 | 3–4 a.m. |
| 6 | ·01 | ·005 | 5 | 1·44 | 2–3 p.m. | — | — |
| 7 | ·01 | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | ·05 | ·02 | 5 | 5·76 | 6–7 a.m. | 2·3 | 7–8 a.m. |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | ·23 | ·10 | 10 | 14·4 ·015 | 10–11 p.m. | 4·5 | 11 p.m.–12 |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | ·25 | ·09 | 20 | 6·48 | 8–9 a.m. | 6·2 | 8–9 a.m. |
| 21 | ·13 | ·02 | 30 | ·96 | 1–2 a.m. | 2·9 | 1–2 a.m. |
| 22 | ·10 | ·095 | 45 | 3·04 | 7–9 a.m. | 3·9 | 8–9 a.m. |
| 23 | — | — | — | — | — | — | — |
| 24 | ·58 | ·14 | 60 | 3·36 | 6–7 a.m. | 7·3 | 6–7 a.m. |
| 25 | ·41 | ·14 | 60 | 3·36 | 9–11 a.m. | 5·6 | 11 a.m.–12 |
| 26 | 1·13 | ·38 | 30 | 18·24 | 1–2 a.m. | 9·4 | 1–2 a.m. |
| 27 | ·17 | ·055 | 10 | 7·92 | 9–10 p.m. | 3·1 | 10–11 p.m. |
| 28 | — | — | — | — | — | — | — |
| 29 | ·005 | — | — | — | — | — | — |
| 30 | ·05 | ·03 | 60 | ·72 | 7–8 a.m. | 2·5 | 8–9 a.m. |

## DECEMBER 1881.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·035 | ·025 | 40 | ·90 | 7–8 a.m. | 2·6 | 8–9 a.m. |
| 2 | ·01 | ·005 | 5 | 1·44 | 11 a.m.–12 | 2·2 | 12–1 p.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | ·01 | — | — | — | — | — | — |
| 5 | ·13 | ·06 | 60 | 1·44 | 10–11 a.m. | 3·8 | 11 a.m.–12 |
| 6 | ·555 | ·37 | 20 | 26·64 | 12–2 a.m. | 11·3 | 3–4 a.m. |
| 7 | — | — | — | — | — | — | — |
| 8 | ·16 | ·06 | 60 | 1·44 | 7–8 a.m. | 4·5 | 8–9 a.m. |
| 9 | ·18 | ·02 | 40 | ·72 | 9–10 a.m. | 4·6 | 9–10 a.m. |
| 10 | ·18 | ·18 | 60 | 4·32 | 9–10 a.m. | 2·6 | 10–11 a.m. |
| 11 | ·075 | ·01 | 15 | ·96 | 5–6 a.m. | 2·4 | 6–7 a.m. |
| 12 | ·18 | ·045 | 30 | 2·16 | 5–6 p.m. | 5·3 | 6–7 p.m. |
| 13 | — | — | — | — | — | — | — |
| 14 | ·06 | ·015 | 60 | ·36 | 4–5 a.m. | 2·7 | 5–6 a.m. |
| 15 | ·04 | ·01 | 50 | ·288 | 8–9 p.m. | — | — |
| 16 | ·255 | ·08 | 60 | 1·92 | 7–9 a.m. | 5·4 | 8–9 a.m. |
| 17 | ·555 | ·09 | 20 | 6·48 | 4–5 a.m. | 6·7 | 5–6 a.m. |
| 18 | — | — | — | — | — | — | — |
| 19 | ·395 | ·285 | 40 | 10·26 | 6–7 a.m. | 11·5 | 6–7 a.m. |
| 20 | ·02 | ·02 | 45 | ·64 | 12–1 a.m. | 2·5 | 1–2 a.m. |
| 21 | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | ·01 | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | ·01 | — | — | — | — | — | — |
| 26 | — | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | ·005 | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

## JANUARY 1882.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·17 | ·095 | 60 | 2·28 | 4–5 p.m. | 5·2 | 5–6 p.m. |
| 2 | ·29 | ·07 | 30 | 3·36 | 4–5 a.m. | 6·1 | 5–6 a.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | ·105 | ·035 | 30 | 1·68 | 3–4 a.m. | 3·5 | 4–5 a.m. |
| 5 | — | — | — | — | — | — | — |
| 6 | ·03 | ·025 | 30 | 1·20 | 2–3 p.m. | 3·6 | 3–4 p.m. |
| 7 | — | — | — | — | — | — | — |
| 8 | ·37 | ·07 | 60 | 1·68 | 2–4 a.m. | 6·3 | 3–4 a.m. |
| 9 | — | — | — | — | — | — | — |
| 10 | ·005 | — | — | — | — | — | — |
| 11 | ·04 | ·015 | 10 | 2·16 | 2–3 p.m. | 2·8 | 3–4 p.m. |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | ·005 | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | ·01 | ·01 | 20 | ·72 | 7–8 a.m. | 2·9 | 8–9 a.m. |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | — | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | ·21 | ·02 | 60 | ·48 | 3–4 p.m. | 6·3 | 3–4 p.m. |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

## FEBRUARY 1882.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | ·005 | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | ·13 | ·03 | 60 | ·72 | 1–3 a.m. | 3·5 | 3–4 a.m. |
| 15 | ·31 | ·03 | 60 | ·72 | 2–3 p.m. | 4·0 | 3–4 p.m. |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | ·01 | ·01 | 60 | ·24 | 6–7 p.m. | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | ·015 | ·005 | 30 | ·24 | 2–3 a.m. | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | ·005 | — | — | — | — | — | — |
| 25 | ·54 | ·035 | 60 | ·84 | 5–6 a.m. | 6·2 | 6–7 a.m. |
| 26 | ·02 | ·01 | 20 | ·72 | 2–3 p.m. | 3·9 | 3–4 p.m. |
| 27 | ·205 | ·015 | 60 | ·36 | 1–2 a.m. | 4·7 | 2–3 p.m. |
| 28 | ·51 | ·01 | 60 | ·24 | 6–7 p.m. | 9·5 | 8–9 p.m. |

## MARCH 1882.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·13 | ·015 | 60 | ·36 | 10–11 p.m. | 5·7 | 10–11 p.m. |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | ·02 | ·015 | 45 | ·48 | 7–9 p.m. | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | ·005 | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | ·095 | ·03 | 60 | ·84 | 4–5 p.m. | 3·7 | 5–6 p.m. |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | ·07 | ·06 | 60 | 1·44 | 9–11 p.m. | 3·1 | 10–11 p.m. |
| 22 | ·02 | ·01 | 60 | ·24 | 2–3 p.m. | 3·3 | 3–4 p.m. |
| 23 | ·015 | ·005 | 60 | ·12 | 4–5 a.m. | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | ·50 | ·025 | 60 | ·60 | 6–7 a.m. | 4·9 | 7–8 a.m. |
| 26 | ·01 | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | ·01 | ·005 | 10 | ·72 | 6–7 p.m. | 2·5 | 7–8 p.m. |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

## APRIL 1882.

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | in. | in. | min. | in. | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | ·05 | ·045 | 10 | 6·48 | 5–6 a.m. | 2·8 | 6–7 a.m. |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | ·075 | ·03 | 30 | 1·44 | 5–6 a.m. | 2·9 | 6–7 a.m. |
| 13 | ·50 | ·175 | 60 | 4·20 | 3–5 p.m. | 5·7 | 4–5 p.m. |
| 14 | ·03 | ·025 | 5 | 7·20 | 10–11 a.m. | 3·1 | 11–12 noon |
| 15 | ·07 | ·055 | 60 | 1·32 | 11 a.m.–12 | 3·2 | 12–1 p.m. |
| 16 | ·015 | — | — | — | — | — | — |
| 17 | ·105 | ·035 | 40 | 1·26 | 5–6 p.m. | 3·1 | 6–7 p.m. |
| 18 | ·005 | — | — | — | — | — | — |
| 19 | ·015 | ·015 | 10 | 2·16 | 5–6 a.m. | 2·8 | 6–7 a.m. |
| 20 | — | — | — | — | — | — | — |
| 21 | — | — | — | — | — | — | — |
| 22 | ·285 | ·095 | 60 | 2·28 | 6–7 a.m. | 4·6 | 6–7 a.m. |
| 23 | ·11 | ·07 | 20 | 5·04 | 5–6 p.m. | 5·4 | 6–7 p.m. |
| 24 | ·15 | ·11 | 20 | 7·92 | 9–11 a.m. | 5·3 | 10–11 a.m. |
| 25 | ·775 | ·16 | 60 | 3·84 | 3–4 p.m. | 6·9 | 3–4 p.m. |
| 26 | ·005 | — | — | — | — | — | — |
| 27 | ·305 | ·12 | 20 | 8·64 | 8–9 a.m. | 4·8 | 9–10 a.m. |
| 28 | ·04 | ·025 | 10 | 3·60 | 4–5 p.m. | 2·9 | 5–6 p.m. |
| 29 | ·40 | ·165 | 60 | 3·96 | 2–3 p.m. | 6·8 | 3–4 p.m. |
| 30 | ·035 | ·015 | 40 | ·54 | 6–7 a.m. | 2·9 | 7–8 a.m. |

## MAY 1882.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·095 | ·05 | 30 | 2·4 | 6–7 a.m. | 3·3 | 7–8 a.m. |
| 2 | — | — | — | — | — | — | — |
| 3 | ·145 | ·08 | 20 | 5·76 | 9–10 a.m. | 4·3 | 10–11 a.m. |
| 4 | ·13 | ·06 | 60 | 1·44 | 11 a.m.–12 | 5·3 | 12–1 p.m. |
| 5 | ·225 | ·07 | 60 | 1·68 | 4–5 p.m. | 5·6 | 5–6 p.m. |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | — | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | ·005 | ·005 | 60 | ·12 | 6–7 a.m. | 2·5 | 7–8 a.m. |
| 21 | — | — | — | — | — | — | — |
| 22 | ·045 | ·02 | 10 | 2·88 | 11 p.m.–12 | 2·5 | 12–1 a.m. |
| 23 | ·02 | ·01 | 10 | 1·44 | 4–5 a.m. | 2·1 | 6–7 a.m. |
| 24 | ·08 | ·02 | 60 | ·48 | 12–1 a.m. | — | — |
| 25 | ·15 | ·07 | 60 | 1·68 | 10 a.m.–12 | 3·8 | 11 a.m.–12 |
| 26 | — | — | — | — | — | — | — |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |
| 31 | — | — | — | — | — | — | — |

## JUNE 1882.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | — | — | — | — | — | — | — |
| | ·075 | ·045 | 15 | 4·32 | 6–7 p.m. | 2·6 | 7–8 p.m. |
| | ·03 | ·015 | 5 | 4·32 | 6–7 p.m. | 2·6 | 6–7 p.m. |
| 4 | ·11 | ·09 | 20 | 6·48 | 7–8 p.m. | 3·1 | 7–8 p.m. |
| 5 | ·095 | ·03 | 10 | 4·32 | 7–8 a.m. | 2·9 | 7–8 a.m. |
| 6 | ·175 | ·11 | 60 | 2·64 | 10 a.m.–12 | 4·7 | 11 a.m.–12 |
| 7 | ·01 | ·01 | 5 | 2·88 | 4–5 p.m. | 2·2 | 5–6 p.m. |
| 8 | ·295 | ·135 | 60 | 3·24 | 8–9 p.m. | 4·7 | 9–10 p.m. |
| 9 | ·19 | ·03 | 30 | 1·44 | 9–10 p.m. | 2·8 | 10–11 p.m. |
| 10 | ·10 | ·05 | 30 | 2·4 | 1–2 a.m. | 3·1 | 2–3 a.m. |
| 11 | ·185 | ·11 | 30 | 5·28 | 4–5 a.m. | 5·2 | 5–6 a.m. |
| 12 | ·02 | ·02 | 5 | 5·76 | 11 a.m.–12 | 2·7 | 11 a.m.–12 |
| 13 | ·095 | ·03 | 60 | ·72 | 7–8 p.m. | 2·8 | 8–9 p.m. |
| 14 | — | — | — | — | — | — | — |
| 15 | ·01 | ·01 | 5 | 2·88 | 2–3 p.m. | 2·2 | 4–5 p.m. |
| 16 | — | — | — | — | — | — | — |
| 17 | ·115 | ·06 | 60 | 1·44 | 3–4 a.m. | 2·6 | 4–5 a.m. |
| 18 | ·205 | ·075 | 30 | 3·60 | 11 a.m.–12 | 4·0 | 12–1 p.m. |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | ·015 | ·005 | 5 | 1·44 | 12–1 a.m. | — | — |
| 22 | ·055 | ·03 | 60 | ·72 | 3–4 p.m. | 2·7 | 4–5 p.m. |
| 23 | ·02 | ·01 | 5 | 2·88 | 1–2 a.m. | 2·1 | 2–3 a.m. |
| 24 | ·36 | ·05 | 60 | 1·20 | 11 p.m.–12 | 5·6 | 11 p.m.–12 |
| 25 | — | — | — | — | — | — | — |
| 26 | ·28 | ·10 | 30 | 4·80 | 11 a.m.–12 | 5·7 | 12–1 p.m. |
| 27 | — | — | — | — | — | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | — | — | — | — | — | — | — |

## JULY 1882.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | — | — | — | — | — | — | — |
| 3 | ·01 | ·01 | 20 | ·72 | 10–11 p.m. | — | — |
| 4 | ·03 | ·03 | 5 | 8·64 | 5–6 a.m. | 2·1 | 6–7 a.m. |
| 5 | ·085 | ·045 | 15 | 4·32 | 8–9 p.m. | 2·3 | 9–10 p.m. |
| 6 | ·12 | ·09 | 45 | 2·88 | 3–5 p.m. | 3·5 | 4–5 p.m. |
| 7 | ·015 | ·01 | 5 | 2·88 | 12–1 p.m. | 2·3 | 1–2 p.m. |
| 8 | ·435 | ·35 | 40 | 12·60 | 10 a.m.–12 | 7·2 | 11 a.m.–12 |
| 9 | ·055 | ·07 | 10 | 3·60 | 2–3 p.m. | 2·5 | 2–3 p.m. |
| 10 | ·085 | ·035 | 30 | 1·68 | 7–9 a.m. | 2·5 | 8–9 a.m. |
| 11 | ·235 | ·07 | 20 | 5·04 | 11–1 p.m. | 4·4 | 12–1 p.m. |
| 12 | ·085 | ·015 | 5 | 4·32 | 2–3 p.m. | 2·5 | 3–4 p.m. |
| 13 | ·01 | ·01 | 10 | 1·44 | 9–10 a.m. | 2·7 | 9–10 a.m. |
| 14 | ·10 | ·085 | 50 | 2·448 | 8–9 a.m. | 4·2 | 9–10 a.m. |
| 15 | ·20 | ·13 | 60 | 3·12 | 9–11 a.m. | 5·7 | 10–11 a.m. |
| 16 | ·005 | — | — | — | — | — | — |
| 17 | ·355 | ·11 | 30 | 5·28 | 10–11 p.m. | 4·9 | 10–11 a.m. |
| 18 | ·08 | ·08 | 60 | 1·92 | 11 p.m.–12 | 2·6 | 12–1 a.m. |
| 19 | — | — | — | — | — | — | — |
| 20 | — | — | — | — | — | — | — |
| 21 | ·035 | ·02 | 40 | ·72 | 5–7 a.m. | 2·0 | 7–8 a.m. |
| 22 | ·03 | ·02 | 40 | ·72 | 2–3 a.m. | 2·1 | 3–4 a.m. |
| 23 | ·01 | ·01 | 5 | 2·88 | 3–4 a.m. | 2·1 | 4–5 a.m. |
| 24 | ·315 | ·16 | 60 | 3·84 | 1–2 p.m. | 5·9 | 2–3 p.m. |
| 25 | ·08 | ·045 | 60 | 1·16 | 9–10 a.m. | 3·8 | 10–11 p.m. |
| 26 | — | — | — | — | — | — | — |
| 27 | ·02 | ·005 | 10 | ·72 | 5–6 a.m. | — | — |
| 28 | — | — | — | — | — | — | — |
| 29 | — | — | — | — | — | — | — |
| 30 | ·04 | ·04 | 20 | 2·88 | 9–10 p.m. | 2·4 | 10–11 p.m. |
| 31 | — | — | — | — | — | — | — |

## AUGUST 1882.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | — | — | — | — | — | — | — |
| 2 | ·015 | ·015 | 15 | 1·44 | 6–7 p.m. | — | — |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | — | — | — | — | — | — | — |
| 6 | — | — | — | — | — | — | — |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | ·04 | ·04 | 10 | 5·76 | 11 p.m.–12 | 1–7 | 12–1 a.m. |
| 13 | — | — | — | — | — | — | — |
| 14 | ·01 | ·005 | 5 | 1·44 | 3–4 p.m. | 1·9 | 4–5 p.m. |
| 15 | ·28 | ·095 | 60 | 2·28 | 7–8 a.m. | 3·2 | 8–9 a.m. |
| 16 | ·03 | ·03 | 50 | ·864 | 7–8 a.m. | 2·4 | 8–9 a.m. |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | ·005 | — | — | — | — | — | — |
| 20 | ·065 | ·065 | 60 | 1·56 | 10–11 p.m. | 2·7 | 11 p.m.–12 |
| 21 | — | — | — | — | — | — | — |
| 22 | ·195 | ·06 | 30 | 2·88 | 9–10 p.m. | 2·5 | 10–11 p.m. |
| 23 | — | — | — | — | — | — | — |
| 24 | ·10 | ·035 | 10 | ·04 | 1–2 p.m. | 2·3 | 2–3 p.m. |
| 25 | ·145 | ·07 | 60 | 1·68 | 12–1 p.m. | 4·9 | 1–2 p.m. |
| 26 | ·065 | ·035 | 5 | 10·08 | 2–3 p.m. | 2·6 | 3–4 p.m. |
| 27 | — | — | — | — | — | — | — |
| 28 | ·01 | ·005 | 5 | 1·44 | 1–2 p.m. | 2·2 | 1–2 p.m. |
| 29 | ·165 | ·15 | 60 | 3·60 | 0–11 a.m. | 5·0 | 11 a.m.–12 |
| 30 | — | — | — | — | — | — | — |
| 31 | ·185 | ·03 | 60 | ? | ?9 p.m. | 3·1 | 9–10 p.m. |

## SEPTEMBER 1882.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | ·12 | ·03 | 50 | ·864 | 12–2 a.m. | 2·5 | 3–4 a.m. |
| 2 | ·095 | ·08 | 30 | 3·84 | 2–3 p.m. | 4·7 | 3–4 p.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | ·36 | ·065 | 45 | 2·08 | 11 a.m.–12 | 3·2 | 12–1 p.m. |
| 6 | ·005 | ·005 | 60 | ·12 | 3–4 p.m. | 2·3 | 4–5 p.m. |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | ·215 | ·11 | 45 | 3·52 | 1–3 a.m. | 4·9 | 2–3 a.m. |
| 12 | ·01 | — | — | — | — | — | — |
| 13 | — | — | — | — | — | — | — |
| 14 | ·125 | ·11 | 60 | 2·64 | 1–2 p.m. | 6·8 | 2–3 p.m. |
| 15 | — | — | — | — | — | — | — |
| 16 | — | — | — | — | — | — | — |
| 17 | — | — | — | — | — | — | — |
| 18 | — | — | — | — | — | — | — |
| 19 | ·65 | ·045 | 5 | 12·96 | 9–10 p.m. | 4·0 | 10–11 p.m. |
| 20 | ·005 | ·005 | 60 | ·12 | 3–4 p.m. | — | — |
| 21 | ·06 | ·02 | 5 | 5·76 | 1–2 p.m. | 3·5 | 1–2 p.m. |
| 22 | — | — | — | — | — | — | — |
| 23 | — | — | — | — | — | — | — |
| 24 | — | — | — | — | — | — | — |
| 25 | — | — | — | — | — | — | — |
| 26 | ·01 | ·01 | 5 | 2·88 | 10–11 p.m. | — | — |
| 27 | ·05 | ·045 | 30 | 2·16 | 2–3 p.m. | 2·7 | 3–4 p.m. |
| 28 | ·86 | ·29 | 50 | 8·352 | 6–8 a.m. | 6·0 | 7–8 a.m. |
| 29 | ·005 | — | — | — | — | — | — |
| 30 | ·005 | — | — | — | — | — | — |

| Day of Month. | Total Quantity of Rain falling in the Day. | Maximum Quantity of Rain falling within any one Hour of the Day. | Time in which maximum Rainfall occurred. | Rate of maximum fall of Rain, if continued for 24 hours. | Time of Day when the maximum fall of Rain occurred. | Proportion of maximum flow of Sewage to mean flow caused by the maximum Rainfall at Croydon. | Time when maximum flow of Sewage occurred in Croydon Sewers. |
|---|---|---|---|---|---|---|---|
| | | OCTOBER 1882. | | | | | |
| | in. | in. | min. | in. | | | |
| 1 | ·075 | ·08 | 5 | 8·64 | 7–8 p.m. | 2·4 | 8–9 p.m. |
| 2 | ·21 | ·21 | 50 | 6·048 | 1–2 a.m. | 8·3 | 2–3 a.m. |
| 3 | — | — | — | — | — | — | — |
| 4 | — | — | — | — | — | — | — |
| 5 | ·07 | ·025 | 10 | 3·60 | 12–1 p.m. | 2·1 | 1–2 p.m. |
| 6 | ·075 | ·02 | 35 | 8·22 | 2–3 a.m. | 1·8 | 3–4 a.m. |
| 7 | — | — | — | — | — | — | — |
| 8 | — | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | ·01 | — | — | — | — | — | — |
| 11 | ·41 | ·095 | 30 | 4·56 | 12–1 p.m. | 3·3 | 1–2 p.m. |
| 12 | ·01 | ·005 | 60 | ·12 | 4–6 p.m. | 1·9 | 4–5 p.m. |
| 13 | ·025 | ·015 | 60 | ·36 | 2–3 a.m. | 1·5 | 3–4 a.m. |
| 14 | — | — | — | — | — | — | — |
| 15 | ·75 | ·125 | 55 | 3·262 | 7–8 a.m. | 6·6 | 7–8 a.m. |
| 16 | ·40 | ·055 | 20 | 3·96 | 10–11 p.m. | 4·3 | 10–11 p.m. |
| 17 | ·025 | ·01 | 60 | ·24 | 9–10 a.m. | 2·2 | 10–11 a.m. |
| 18 | ·005 | ·005 | 5 | 1·44 | 7–8 a.m. | — | — |
| 19 | ·175 | ·06 | 60 | 1·44 | 9–11 p.m. | 3·8 | 10–11 p.m. |
| 20 | ·175 | ·10 | 60 | 2·40 | 7–9 a.m. | 4·8 | 8–9 a.m. |
| 21 | ·69 | ·11 | 35 | 4·525 | 9–10 a.m. | 6·0 | 10–11 a.m. |
| 22 | ·02 | ·015 | 5 | 4·32 | 11–a.m.–12 | 2·5 | 12–1 p.m. |
| 23 | ·495 | ·225 | 60 | 5·40 | 7–9 a.m. | 8·5 | 8–9 a.m. |
| 24 | ·26 | ·118 | 40 | 4·248 | 9–11 a.m. | 7·3 | 10–11 a.m. |
| 25 | ·005 | ·005 | 15 | ·480 | 4–5 p.m. | 2·3 | 4–5 p.m. |
| 26 | ·21 | ·11 | 30 | 5·28 | 6–7 p.m. | 5·6 | 6–7 p.m. |
| 27 | ·95 | ·15 | 60 | 3·60 | 6–7 a.m. | 6·2 | 7–8 a.m. |
| 28 | ·545 | ·115 | 60 | 2·76 | 10–11 a.m. | 5·3 | 11 a.m.–12 |
| 29 | ·005 | — | — | — | — | — | — |
| 30 | ·20 | ·025 | 15 | 2·40 | 1–2 p.m. | 3·6 | 3–4 p.m. |
| 31 | — | — | — | — | — | — | — |
| | | NOVEMBER 1882. | | | | | |
| 1 | ·03 | ·01 | 40 | ·36 | 4–5 p.m. | 2·5 | 5–6 p.m. |
| 2 | ·10 | ·06 | 5 | 17·28 | 7–8 p.m. | 3·7 | 8–9 p.m. |
| 3 | ·13 | ·06 | 40 | 2·16 | 11 a.m.–12 | 2·5 | 12–1 p.m. |
| 4 | ·01 | ·005 | 60 | ·12 | 1–2 p.m. | 2·2 | 2–3 p.m. |
| 5 | ·03 | ·015 | 5 | 4·32 | 9–10 p.m. | 2·2 | 10–11 p.m. |
| 6 | ·16 | ·07 | 50 | 2·016 | 3–4 p.m. | 3·4 | 4–5 p.m. |
| 7 | ·32 | ·275 | 60 | 6·60 | 10–11 p.m. | 10·4 | 11 p.m.–12 |
| 8 | ·005 | ·005 | 60 | ·12 | 1–2 p.m. | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | ·13 | ·05 | 50 | ·144 | 6–7 a.m. | 3·7 | 8–9 a.m. |
| 13 | ·02 | — | — | — | — | — | — |
| 14 | — | — | — | — | — | — | — |
| 15 | ·33 | ·08 | 60 | 1·92 | 8–9 a.m. | 4·4 | 8–9 a.m. |
| 16 | ·15 | ·025 | 40 | ·90 | 11 a.m.–12 | 5·5 | 11 a.m.–12 |
| 17 | — | — | — | — | — | — | — |
| 18 | ·145 | ·065 | 20 | 4·68 | 11 p.m.–12 | 3·4 | 12–1 a.m. |
| 19 | ·01 | ·005 | 5 | 1·44 | 9–10 a.m. | 2·2 | 10–11 a.m. |
| 20 | ·03 | ·02 | 25 | 1·152 | 12–1 p.m. | 2·5 | 1–2 p.m. |
| 21 | ·11 | ·05 | 40 | 1·80 | 4–6 a.m. | 1·4 | 5–6 a.m. |
| 22 | — | — | — | — | — | — | — |
| 23 | ·225 | ·065 | 30 | 3·12 | 2–3 a.m. | 3·3 | 3–4 a.m. |
| 24 | — | — | — | — | — | — | — |
| 25 | ·02 | ·01 | 5 | 2·88 | 4–5 p.m. | 2·2 | 4–5 p.m. |
| 26 | — | — | — | — | — | — | — |
| 27 | ·005 | — | — | — | — | — | — |
| 28 | ·23 | ·085 | 30 | 4·08 | 3–5 a.m. | 2·9 | 5–6 a.m. |
| 29 | ·04 | ·01 | 20 | ·72 | 4–5 a.m. | 1·8 | 5–6 a.m. |
| 30 | — | — | — | — | — | — | — |
| | | DECEMBER 1882. | | | | | |
| 1 | — | — | — | — | — | — | — |
| 2 | ·14 | ·045 | 30 | 2·16 | 4–5 p.m. | 2·1 | 4–5 p.m. |
| 3 | ·08 | — | — | — | — | — | — |
| 4 | ·03 | ·015 | 10 | 2·16 | 4–5 a.m. | 2·1 | 5–6 a.m. |
| 5 | ·01 | — | — | — | — | — | — |
| 6 | ·02 | ·02 | 10 | 2·88 | 11 a.m.–12 | 2·3 | 12–1 p.m. |
| 7 | ·54 | ·085 | 60 | 2·04 | 4–5 p.m. | 2·2 | 4–5 p.m. |
| 8 | ·005 | — | — | — | — | — | — |
| 9 | — | — | — | — | — | — | — |
| 10 | — | — | — | — | — | — | — |
| 11 | — | — | — | — | — | — | — |
| 12 | ·02 | ·01 | 40 | ·36 | 2–3 a.m. | 2·1 | 3–4 a.m. |
| 13 | ·01 | — | — | — | — | — | — |
| 14 | ·01 | — | — | — | — | — | — |
| 15 | ·025 | ·01 | 30 | ·48 | 8–9 p.m. | 2·2 | 9–10 p.m. |
| 16 | ·015 | ·005 | 10 | ·72 | 9–10 p.m. | 2·3 | 9–10 p.m. |
| 17 | ·035 | ·005 | 20 | ·36 | 8–9 a.m. | 2·6 | 9–10 a.m. |
| 18 | — | — | — | — | — | — | — |
| 19 | — | — | — | — | — | — | — |
| 20 | ·04 | ·02 | 40 | ·72 | 7–9 a.m. | 2·7 | 8–9 a.m. |
| 21 | ·005 | — | — | — | — | — | — |
| 22 | ·09 | ·04 | 60 | ·96 | 8–10 p.m. | 3·0 | 10–11 p.m. |
| 23 | — | — | — | — | — | — | — |
| 24 | ·025 | ·02 | 60 | ·48 | 2–3 a.m. | 2·5 | 3–4 a.m. |
| 25 | ·22 | ·035 | 20 | 2·52 | 11–1 p.m. | 3·2 | 1–2 p.m. |
| 26 | ·18 | ·07 | 60 | 1·68 | 8–10 p.m. | 4·6 | 10–11 p.m. |
| 27 | ·025 | ·015 | 20 | 1·08 | 1–2 p.m. | 2·6 | 1–2 p.m. |
| 28 | ·01 | ·01 | 10 | 1·44 | 6–7 a.m. | 2·3 | 7–8 a.m. |
| 29 | ·13 | ·13 | 60 | 3·12 | 8–9 a.m. | 5·8 | 9–10 a.m. |
| 30 | ·215 | ·095 | 60 | 2·28 | 9–11 a.m. | 5·9 | 11 a.m.–12 |
| 31 | ·21 | ·065 | 60 | 1·56 | 11–1 a.m. | 3·8 | 1–2 a.m. |

## APPENDIX A.F. (1).



### DETERMINATION OF THE EFFECT OF THE MIXING ACTION, IN THE WATER OF THE RIVER THAMES, BY THE AID OF THE CHLORINE TEST.

By William Pole, F.R.S., Mem. Inst. C.E.

A Tidal estuary receives, from an outfall at a certain point, a flow of sewage = S cubic feet per minute, and containing $c_2$ grains of chlorine in every cubic foot.

At various points above this the estuary receives a flow of land water, in all = L cubic feet per minute, and containing $c_1$ grains of chlorine in a cubic foot.

It may also receive, at its mouth, from the incoming tide, sea water containing $c_3$ grains of chlorine in a cubic foot.

Samples of water are taken at various points of the estuary, above and below the sewage outfall, and the quantity of chlorine in each is found by analysis. It is also found, by taking several samples at the same section, that the composition of the water is fairly homogeneous throughout the cross area of the river.

Given then the number of grains of chlorine, = C, in a cubic foot taken at any point, it is required to determine the proportion of land water, sewage, and sea water respectively at that point.

The problem must be solved separately for the lengths of the estuary below and above the sewage outlet respectively.

*First: Below the Sewage Outfall.*

Let A = the area of the river at the point where the sample is taken, in square feet. Then the quantity of water in one foot length at that section will be = A cubic feet, and the total quantity of chlorine in that quantity will be—

= A C.

Let $x$ = cubic feet of land water.
„ $y$ = „ sewage.
„ $z$ = „ sea water.
in the quantity A.

Then we have the equations—
(I.) $x+y+z = A$ and
(II.) $xc_1 + yc_2 + zc_3 = AC$.

But as the land water and the sewage have gone down together from the site of the outfall, and have become thoroughly mixed, there is every reason to conclude

App. A.F. (1). that they will retain the proportions of their origin, *i.e.*, that $\frac{x}{y} = \frac{L}{S}$ whence

$$\text{III.} \begin{cases} \frac{y}{A} = \frac{c_3 - C}{\left(\frac{L}{S} + 1\right) c_3 - \frac{L}{S} c_1 - c_2} \\ \frac{z}{A} = 1 - \left(\frac{L}{S} + 1\right) \frac{y}{A} \\ \frac{x}{A} = \frac{L}{S} \frac{y}{A} \end{cases}$$

which determine the proportions of the various elements in the mixture *at any point below the sewage outfall*. The equations may also be taken as applicable near the outfall itself.

*Secondly.—Above the Sewage Outfall.*

The formulæ given above will not apply here, because the assumption that $\frac{x}{y} = \frac{L}{S}$ will obviously not hold good *above* the outfall.

For this locality, the assumption must be reversed, and made to apply not to the land, but to the *sea* water. The sea water as it passes the sewage outfall will naturally carry a portion of the sewage with it; and since, in all parts of the river the different constituents are found uniformly mixed, it may be fairly assumed that, in all parts above the sewage outfall, the proportion of sea water and sewage water will remain the same as it was *at* the outfall; for having been once mixed there in that proportion, there is no reason why, in travelling upwards, the proportion should be altered.

Now it may be found by the equations (III.) what this proportion is at the outfall; let this be—

$$\frac{\text{Sea water}}{\text{Sewage}} = r.$$

Then for all places above the outfall—

$$\frac{z}{y} = r.$$

Substituting in equations I. and II., we get—

$$\text{IV.} \begin{cases} \frac{y}{A} = \frac{C - c_1}{c_2 + r c_3 - (r+1) c_1}. \\ \frac{x}{A} = 1 - (r+1) \frac{y}{A}. \\ \frac{z}{A} = r \frac{y}{A}. \end{cases}$$

Which determine the proportions of the various elements in the mixture at *any point above the sewage outfall*.

For simplicity of reasoning the quantities of chlorine have been assumed to be given in grains per cubic foot, but it is evident, from the form of the equations, that any other denomination may be substituted. They happen to be given in parts per 100,000 by weight, and the fixed quantities used in the calculations of this matter by the various witnesses are—

$$c_1 = 1{\cdot}7.$$
$$c_2 = 10{\cdot}.$$
$$c_3 = 1961{\cdot}.$$

Inserting these the equations become—

$$\text{(III.)} \quad \frac{y}{A} = \frac{1961 - C}{1961 \left(\frac{L}{S} + 1\right) - 1{\cdot}7 \frac{L}{S} - 10}.$$

$$\text{(IV.)} \quad \frac{y}{A} = \frac{C - 1{\cdot}7}{10 + 1961\, r - 1{\cdot}7\,(r+1)}.$$

$\frac{x}{A}$ and $\frac{z}{A}$ in both cases as before.

By these equations the following tables are calculated.

---

Approximate Composition of the Water at different points of the River Thames, as shown by the Chlorine Tests.

*(The following results are laid down graphically on the accompanying diagrams,* A.F. (2)).

I.

September 14, 1882.
Land water about 25 per cent. under the average.
Spring tide. High water.

$$\frac{L}{S} = \frac{93{,}167}{16{,}090} = 5{\cdot}79$$
$$r = 5 \text{ nearly.}$$

| | Miles from Teddington. | Chlorine in 100,000. | Per centage of Land Water | Per centage of Sewage. | Per centage of Sea Water. |
|---|---|---|---|---|---|
| Teddington | 0 | 1·7 | 100· | 0 | 0 |
| Chiswick | 9·2 | 4·7 | 99·8 | 0 | 0·2 |
| St. Paul's Pier | 18·4 | 210·7 | 87·2 | 2·1 | 10·7 |
| Deptford | 23·1 | 438· | 73·3 | 4·5 | 22·2 |
| North Woolwich | 28·7 | 671· | 59·2 | 6·8 | 34·0 |
| Sewage Outfalls | 31·7 | 831·5 | 49·2 | 8·5 | 42·3 |
| Erith | 35·7 | 1031· | 40·4 | 7·0 | 52·6 |
| Gravesend | 46·5 | 1502· | 20· | 3·5 | 76·5 |
| Southend | 62·5 | 1931· | 1·3 | 0·2 | 98·5 |
| The Sea | — | 1961· | 0 | 0 | 100· |

Ia.

Same day. Low water.

$$\frac{L}{S} = 5{\cdot}79$$
$$r = 1{\cdot}69.$$

| | | | | |
|---|---|---|---|---|
| Teddington | 1·7 | 100· | 0 | 0 |
| Chiswick | 1·9 | 100· | 0 | 0 |
| St. Paul's | 4·1 | 99·9 | 0 | 0·1 |
| Deptford | 49· | 96·2 | 1·4 | 2·4 |
| North Woolwich | 180· | 85·7 | 5·3 | 9·0 |
| Sewage Outfalls | 394·5 | 68·3 | 11·8 | 19·9 |
| Erith | 530· | 62·2 | 10·7 | 27·1 |
| Gravesend | 1058· | 39·4 | 6·8 | 54·8 |
| Southend | 1765· | 9·0 | 1·5 | 89·5 |
| The Sea | 1961· | 0· | 0 | 100· |

II.

September 22, 1882.
Land water about 10 per cent. above the average.
Neap tide. High water.

$$\frac{L}{S} = \frac{134{,}064}{16{,}090} = 8{\cdot}33$$
$$r = 5{\cdot}12.$$

| | | | | |
|---|---|---|---|---|
| Teddington | 1·7 | 100· | 0 | 0 |
| Chiswick | 1·9 | 100· | 0 | 0 |
| St. Paul's | 89· | 95·5 | 0·9 | 4·6 |
| Deptford | 311· | 81·0 | 3·1 | 15·9 |
| North Woolwich | 581· | 64·4 | 5·8 | 29·8 |
| Sewage Outfalls | 696· | 57·7 | 6·9 | 35·4 |
| Erith | 886· | 49·1 | 5·9 | 45·0 |
| Gravesend | 1352· | 27·8 | 3·3 | 68·9 |
| Southend | 1891· | 3·2 | 0·4 | 96·4 |
| The Sea | 1961· | 0 | 0 | 100· |

IIa.

Same day. Low water.

$$\frac{L}{S} = 8{\cdot}33$$
$$r = 2{\cdot}1.$$

| | | | | |
|---|---|---|---|---|
| Teddington | 1·7 | 100· | 0 | 0 |
| Chiswick | 1·8 | 100· | 0 | 0 |
| St. Paul's | 2·4 | 99·9 | 0 | 0·1 |
| Deptford | 28·8 | 98·1 | 0·6 | 1·3 |
| North Woolwich | 162· | 88·0 | 3·9 | 8·1 |
| Sewage Outfalls | 360· | 73·0 | 8·7 | 18·3 |
| Erith | 555· | 64·2 | 7·7 | 28·1 |
| Gravesend | 1062· | 40·9 | 4·9 | 54·2 |
| Southend | 1816· | 7·5 | 0·8 | 91·7 |
| The Sea | 1961· | 0 | 0 | 100· |

III.

30 November 1882.

Land water about $4\frac{1}{4}$ times the average.

High Water.

$$\frac{L}{S} = \frac{522 \cdot 931}{15 \cdot 012} = 34 \cdot 8$$

$$r = 4 \cdot 2.$$

| | Chlorine in 100,000. | Per centage of | | |
|---|---|---|---|---|
| | | Land Water. | Sewage. | Sea Water. |
| Teddington | 1·7 | 100· | 0 | 0 |
| Chiswick | 1·7 | 100· | 0 | 0 |
| St. Paul's | 2·8 | 100· | 0 | 0 |
| Deptford | 20· | 99· | 0·2 | 0·8 |
| North Woolwich | 118· | 93·4 | 1·3 | 5·3 |
| Sewage Outfalls | 214· | 87·0 | 2·5 | 10·5 |
| Erith | 314· | 80·0 | 2·3 | 17·7 |
| Gravesend | — | — | — | — |
| Southend | 1785· | 8·7 | 0·2 | 91·1 |
| The Sea | 1961· | 0 | 0 | 100· |

IIIa.

Same day. Low Water.

$$\frac{L}{S} = 34 \cdot 8$$

$$r = 0 \cdot 18$$

| | | | | |
|---|---|---|---|---|
| Teddington | 1·7 | 100· | 0 | 0 |
| Chiswick | 1·7 | 100· | 0 | 0 |
| St. Paul's | 1·9 | 100· | 0 | 0 |
| Deptford | 1·9 | 100· | 0 | 0 |
| North Woolwich | 3·1 | 99·6 | 0·4 | 0 |
| Sewage Outfalls | 12· | 96·7 | 2·8 | 0·5 |
| Erith | 84· | 93·0 | 2·7 | 4·3 |
| Gravesend | — | — | — | — |
| Southend | 1523· | 21·6 | 0·6 | 77·8 |
| The Sea | 1961· | 0 | 0 | 100· |

None of these chlorine tests happen to have been made at the time which is of the greatest importance in the inquiry, namely, in the driest weather. The inflow of fresh water on the 14th September was below the average, but it was much more than the minimum. In the absence, therefore, of any direct data, it is worth while to see if a rough estimate can be made of what the effect might be in the driest time.

The three amounts of inflow given vary considerably, and by examining the effect of the variation it may be possible to form some empirical rule by which the effect may be carried farther.

We may take as the element to be found the maximum proportion of sewage in the river at both high and low water; it is obvious that this will become greater as the inflow of water is less; and a critical examination of the nature of the increments will show that the quantities may be represented, empirically, by an expression of the following form.

Let Y = the maximum proportion of sewage in 1,000 parts of the river, and L = the inflow of fresh water; then—

$$(Y + \alpha)^2 = \beta \left( \frac{10,000,000}{L} + \gamma \right)$$

Where $\alpha$, $\beta$, and $\gamma$, are constants differing for high and low water respectively. They may be taken approximately as follows:—

For high water $\alpha = 0$; $\beta = 75$; $\gamma = -10$.

„ low „ $\alpha = 60$; $\beta = 270$; $\gamma = +10$.

The following tables show the result of this mode of estimation. App. A.F. (1).

| At High Water. | Inflow of Land water, in cubic feet per minute. | Parts of Sewage in 100 parts of River water near the Outfalls. |
|---|---|---|
| 1882. | | |
| November 30 | 522·000 | 2·5 |
| September 22 | 134·000 | 7·0 |
| September 14 | 93·167 | 8·5 |
| *In dry weather, minimum flow (Estimated)* | *48·500* | *12·0* |
| **At Low Water.** | | |
| November 30 | 522·000 | 2·8 |
| September 22 | 134·000 | 8·7 |
| September 14 | 93·167 | 11·8 |
| *In dry weather, minimum flow (Estimated)* | *48·500* | *18·0* |

According to this estimate therefore, in dry weather, at low water, no less than 18 per cent of the river near the outfalls may consist of liquid which has been discharged from the sewer. The distribution over the length of the river may easily be estimated, by the former results.

The mean rate of permanent progress of the sewage down the river at any place will be equal to the quantity of land water and sewage travelling down divided by the area of section at that place occupied by the two together at mean tide level, $= \frac{L \quad S}{x + y}$. The result for each of the days calculated is given in the following table.

| | Total sectional area, mean tide level. | Nov. 30. | Sept. 22. | Sept. 14. | Dry weather. (Estimated.) | |
|---|---|---|---|---|---|---|
| L + S in cubic feet per minute | — | 537,943 | 150,154 | 109,257 | 64,000 | |
| | | *Downward Progress in miles per diem.* | | | | |
| At the Outfalls | 50,200 | 3·1 | 1·1 | 0·85 | | 0·6 |
| At Erith | 70,475 | 2·3 | 0·91 | 0·71 | | |
| At Gravesend | 96,674 | — | 1·1 | 0·87 | | |

There appears to be some uncertainty about the values of the data $c_2$ and $c_3$. The quantity of chlorine in normal sewage has been taken here at 10 parts in 100,000, but some chemists believe it to be higher, ranging between 10 and 20. It will, however, be evident by a glance at equations III. and IV. that any variation between these limits cannot have any appreciable influence on the value of $y$; the difference, if $c_2$ were made = 20, would be less than $\frac{1}{10}$ per cent; the reason of this is, that the proportion of sewage in the water is deduced chiefly from the proportions of the sea and land water in the mixture, and not from the chlorine in the sewage, which only enters into the equation as a slight correction.

The quantity of chlorine in sea water has been taken as 1961; but it varies considerably in different places. Here again the equations will show that a moderate change in this datum will not have much effect. For example, a variation of 50 parts either way would not, in the most important case, vary the result one per cent. The important element is the quantity C (the chlorine at the point taken) and if this is correct the results given in the tables cannot be materially wrong.

The ratio $\frac{L}{S}$ is assumed to have been constant, or nearly so, for some time before the observation; but, strictly, this ratio should apply to the period when the water, at the point calculated, may be assumed to have passed the outlets.

App. A.H.

## APPENDIX A.H.

See Q. 10, 847.

REPORT on the SUSPENDED MATTER in LONDON SEWAGE by PROFESSOR E. FRANKL AND, F.R.S.

In recent inquiries into the composition and polluting power of London sewage, scarcely any notice has been taken of the effect of rainfall upon the proportional and absolute amount of suspended matter or mud discharged from the outfalls.

Inasmuch, however, as every ·01 inch of rain augments the volume of London sewage by upwards of 14,000,000 gallons, and as all analyses point to the conclusion that the heavier the rainfall the larger the proportion of suspended matter in the sewage, it follows that any estimates based upon the dry weather flow of sewage and its chemical composition must be exceedingly incorrect; for whilst in 76 samples of dry weather sewage (even when all dry weather samples containing an abnormally large amount of suspended matter were excluded) there was on the average 23·36 grains of suspended matter; 9 samples of sewage, collected on days when the rainfall was 0·1 inch and upwards, averaged no less than 134·94 grains of suspended matter per gallon.

I have, therefore, compiled tables showing :—

1. The rainfall on every day during the years 1878 and 1879.
2. A short (official) description of the way in which rain fell on each occasion.
3. The average number of grains of suspended matter contained in a gallon of sewage discharged into the Thames :—
   (*a.*) In fair weather;
   (*b.*) In rainy weather when the daily rainfall does not exceed 0·03 inch;
   (*c.*) Ditto when the daily rainfall is above 0·03 inch, but under 0·1 inch.
   (*d.*) Ditto when the daily rainfall is 0·1 inch and over.
   Also the actual and average amounts of mineral and organic matter contained in the suspended matter in each of these cases.
4. The number of gallons of sewage entering the Thames each day in 1878 and 1879.
5. The number of tons of dry suspended matter discharged into the Thames each day, and the number of tons of wet mud to which this would be equivalent, on the supposition that 1 ton of dry suspended matter forms 3 tons of wet mud.
6. The total amount of dry and wet mud discharged into the Thames during each of the years 1878 and 1879.
7. The average percentages of organic and mineral matter in fair weather sewage, in storm sewage, and in the aggregate mud discharged in each of the two years.

These tables are appended to this Report.

Table A contains the information mentioned in paragraphs 1 and 2. It is compiled from the Meteorological Observations made at the Royal Observatory, Greenwich, under the superintendance of the Astronomer Royal, and published in the "Weekly Returns of Births, Deaths, &c.," issued by the Registrar General.

Table B shows the results of analysis, actual and average, as regards suspended matter, of 82 samples of fair-weather London sewage, of 10 samples when the rainfall did not exceed ·03 inch in 24 hours, of 2 samples when it was above ·03 inch, but under ·1 inch, and of 11 samples taken on days when the rainfall was ·1 inch and upwards. The analyses executed by Messrs. Hofmann and Witt are marked with an asterisk, and those made by Mr. Keates with an obelisk †. The unmarked analyses are my own. All the analyses are given in the Table, but such as are obviously abnormal are ruled out and excluded from the averages. This table also contains the rainfall, if any, and remarks on the weather.

Table C gives, for the years 1878 and 1879, the number of days when no rain fell, and the number under each particular depth of rain, together with the information mentioned in paragraphs Nos. 4, 5, and 6. In this table the rain is calculated as falling upon 122 square miles, and 20°/₀ is allowed for evaporation, which is probably much in excess of the truth. On the rainless days the volume of the sewage is reckoned as equal to the average daily water supply, which was 129,657,848 gallons in 1878, and 134,443,669 gallons in 1879. I have taken, however, the round numbers, 130,000,000 and 134,000,000, in the Table. On the rainy days these volumes are added to the rainfall minus 20°/₀, to find the total volume of sewage. This daily sewage rate is given in the fourth column of the table, whilst the fifth column records the number of tons of dry suspended matter contained in this volume of sewage, multiplied by the number of days (given in the first column) during which this rate of flow prevailed. The dry suspended matter is converted into wet mud, in this table, by multiplying it by 3. This multiplier is probably rather too high, and I have therefore given separately the aggregate weight of wet mud discharged in each of the two years, on the assumption that it contains only 60°/₀ of water, which is the proportion actually found by Dr. Tidy in the mud deposits of the tidal Thames.

Table D shows the aggregate number of tons of dry organic, mineral, and total suspended matter in the four average varieties of sewage discharged into the Thames in each of the years 1878 and 1879, and defined in table B. The numbers in this table show strikingly how enormously the proportion of mineral matter in the sewage mud is raised in wet weather; for whilst the percentage in dry-weather mud is only 40·41, it rises to 44·16 with a rainfall not exceeding ·03 inch, to 65·38 when the rainfall is above ·03 but under ·1, and to no less than 75·16, when the rainfall is above ·1 inch.

In this table the wet mud is assumed to contain 60°/₀ of water.

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### TABLE A.

RAINFALL and WEATHER OBSERVATIONS for the Years 1878 and 1879.

| 1878. | Rainfall. | Remarks. |
|---|---|---|
| Jan. 1 | ·00 inch. | |
| „ 2 | ·02 „ | Overcast; thin rain and fog. |
| „ 3 | ·05 „ | Fine and partially cloudy in morning; rain fell occasionally in afternoon and evening. |
| „ 4 | ·22 „ | Overcast; frequent rain. |
| „ 5 | ·02 „ | „ „ „ |
| „ 6 | ·01 „ | Generally overcast; a little rain fell in the early morning hours. |
| „ 7 | ·01 „ | Partially cloudy; fine throughout morning; slight rain in afternon. |
| „ 8 to 14 | ·00 „ | |
| „ 15 | ·02 „ | Overcast generally; rain in morning. |
| „ 16 to 22 | ·00 „ | |
| „ 23 | ·06 „ | Heavy squall of wind and rain in early morning; showery at times. |
| „ 24 | ·00 „ | |
| „ 25 | ·05 „ | Variable; occasional showers of rain and snow. |
| „ 26 | ·00 „ | |
| „ 27 | ·02 „ | Overcast; occasional rain. |
| „ 28 | ·39 „ | „ with heavy rain till afternoon. |
| „ 29 to 31 | ·00 „ | |
| Feb. 1 | ·00 „ | |
| „ 2 | ·01 „ | Overcast; occasional thin rain. |
| „ 3 | ·00 „ | |
| „ 4 | ·03 „ | „ rain in morning. |
| „ 5 | ·01 „ | „ rain fell in the early morning. |
| „ 6 to 8 | ·00 „ | |
| „ 9 | ·01 „ | „ rain in morning. |
| „ 10 | ·16 „ | „ rain and fog. |
| „ 11 | ·00 „ | |
| „ 12 | ·03 „ | A fine day; overcast with rain after 11 p.m. |
| „ 13 | ·08 „ | Overcast, with slight exceptions; rain fell during the morning. |
| „ 14 | ·51 „ | Overcast, rain fell throughout the morning until p.m. |
| „ 15 | ·02 „ | Cloudy hin rain fell in the evening. |
| „ 16 & 17 | ·00 „ | |
| „ 18 | ·03 „ | Cloudy in morning, and a showery rain fell between 5 and 6 a.m. |
| „ 19 to 26 | ·00 „ | |
| „ 27 | ·19 „ | Overcast; rain fell throughout the afternoon and evening. |
| „ 28 | ·02 „ | Overcast; occasional rain. |
| March 1 | ·11 „ | Overcast; frequent rain. |
| „ 2 | ·02 „ | Rain fell in the early morning hours. |
| „ 3 to 9 | ·00 „ | |
| „ 10 | ·08 „ | Overcast; gloomy and rainy in the morning; fine in the afternoon. |
| „ 11 | ·00 „ | |
| „ 12 | ·01 „ | Cloudy, with slight rain in morning. |
| „ 13 to 23 | ·00 „ | |

Rainfall and Weather Observations for the Years 1878 and 1879—(*continued*).

| 1878. | Rainfall. | Remarks. |
|---|---|---|
| March 24 - | ·02 inch. | A little snow fell in early morning hours; fine till 4 p.m.; snow fell thickly till 5.30 p.m. |
| „ 25 - | ·01 „ | Snow fell in the morning, with occasional rain in the afternoon. |
| „ 26 - | ·00 „ | |
| „ 27 - | ·01 „ | Snow fell in the morning. |
| „ 28 - | ·21 „ | Overcast generally; rain and snow fell in the evening. |
| „ 29 - | ·39 „ | Overcast; snow fell thickly throughout the morning. |
| „ 30 - | ·07 „ | Cloudy; snow and rain fell occasionally. |
| „ 31 - | ·13 „ | Overcast, with rain and snow in afternoon and evening. |
| April 1 - | ·01 „ | Snow fell in the early morning hours; slight showers in the afternoon. |
| „ 2 - | ·01 „ | Partially cloudy till evening, with showers in the afternoon. |
| „ 3 - | ·17 „ | Overcast, with rain till evening. |
| „ 4 - | ·00 „ | |
| „ 5 - | ·06 „ | Partially cloudy till evening, with showers of rain accompanied by thunder and lightning. |
| „ 6 to 9 | ·00 „ | |
| „ 10 - | ·31 „ | Generally cloudy; rain commenced falling at 5 p.m., and was still falling at midnight. |
| „ 11 - | 2·51 „ | Rain fell heavily throughout the morning and until 1.40 p.m., having fallen continuously for nearly 21 hours |
| „ 12 - | ·00 „ | |
| „ 13 - | ·03 „ | Partially cloudy during morning; overcast, with rain in afternoon and evening. |
| „ 14 & 15 | ·00 „ | |
| „ 16 - | ·12 „ | Overcast; frequent rain; very gloomy in afternoon. |
| „ 17 - | ·16 „ | Cloudy; frequent showers; lightning and thunder in afternoon. |
| „ 18 - | ·00 „ | |
| „ 19 - | ·02 „ | Overcast, with rain in morning; fine and partially cloudy during the day; showery at night. |
| „ 20 - | ·43 „ | Overcast, with continuous rain from early morning until afternoon; fine afterwards. |
| „ 21 - | ·09 „ | Fine and partially cloudy till evening; overcast, with heavy rain at night. |
| „ 22 & 23 | ·00 „ | |
| „ 24 - | ·11 „ | Overcast, with frequent rain till afternoon, fine afterwards. |
| „ 25 to 28 | ·00 „ | |
| „ 29 - | ·08 „ | Rain fell throughout the afternoon and evening. |
| „ 30 - | ·20 „ | Rain fell frequently during the morning. |
| May 1 - | ·38 „ | Showery in morning; fine but cloudy in afternoon; overcast with rain at night. |
| „ 2 to 5 | ·00 „ | |
| „ 6 - | ·03 „ | Generally cloudy; rain fell at night. |
| „ 7 - | 1·52 „ | Rain fell very heavily from 5.33 p.m. to 7.30 p.m.; 1 inch rain between 6 and 6.50 p.m. |
| „ 8 - | ·30 „ | Rain fell all the morning until about 9.30 a.m.; slight showers fell till noon. |
| „ 9 - | ·02 „ | Rain fell at night. |
| „ 10 - | ·18 „ | Fine day; lightning at night; rain fell heavily between 10 p.m. and midnight. |
| „ 11 - | ·05 „ | Rain in the morning. |
| „ 12 - | ·00 „ | |
| „ 13 - | ·14 „ | Heavy rain fell in morning. |
| „ 14 - | ·02 „ | Cloudy; showery. |
| „ 15 - | ·19 „ | „ „ heavy rain at night. |
| „ 16 - | ·03 „ | Generally cloudy; rain throughout afternoon and evening. |
| „ 17 - | ·00 „ | |
| „ 18 - | ·25 „ | Frequent heavy showers of rain with thunder and lightning in morning. |
| „ 19 - | ·00 „ | |
| „ 20 - | ·22 „ | Cloudy; frequent rain. |
| „ 21 - | ·06 „ | „ showery. |
| „ 22 - | ·00 „ | |
| „ 23 - | ·32 „ | Cloudy; rain fell heavily in the morning. |
| „ 24 - | ·20 „ | Generally cloudy; rain fell frequently in afternoon and evening. |
| „ 25 - | ·01 „ | Occasional slight showers. |
| „ 26 - | ·07 „ | Showery. |
| „ 27 - | ·01 „ | Occasional light showers. |
| „ 28 - | ·28 „ | Overcast generally; rain at night. |
| „ 29 - | ·04 „ | „ rain fell in morning. |
| „ 30 - | ·00 „ | |
| „ 31 - | ·01 „ | A little rain at night. |
| June 1 - | ·00 „ | |
| „ 2 - | ·00 „ | |
| „ 3 - | ·03 „ | Rain fell in early morning. |
| „ 4 - | ·30 „ | Variable; rain fell very heavily in the early morning, and occasional showers fell in the afternoon and evening. |
| „ 5 - | ·07 „ | Overcast and showery till evening. |
| „ 6 & 7 | ·00 „ | |
| „ 8 - | ·40 „ | Cloudy; thunderstorm between 4 p.m. and 5 p.m. |
| „ 9 - | ·01 „ | Cloudy and showery in morning; fine afterwards. |
| „ 10 - | ·07 „ | Partially cloudy; showery; thunder in afternoon. |
| „ 11 - | ·02 „ | Showery till evening. |
| „ 12 - | ·12 „ | Occasional showers of rain. |
| „ 13 - | 1·05 „ | None in the morning; very heavy in the afternoon. |
| „ 14 - | ·01 „ | A little rain in early morning. |
| „ 15 - | ·00 „ | |
| „ 16 - | ·98 „ | Rain fell heavily in early morning hours; heavy rain fell also in evening. |
| „ 17 - | ·01 „ | Showery in afternoon. |
| „ 18 to 22 | ·00 „ | |
| „ 23 - | ·61 „ | Violent thunderstorm in afternoon. |
| „ 24 to 29 | ·00 „ | |
| „ 30 - | ·89 „ | Frequent rain with thunder during the day. |

Rainfall and Weather Observations for the Years 1878 and 1879—(*continued*).

App. A.H.

| 1878. | Rainfall. | Remarks. |
|---|---|---|
| July 1 - | ·00 inch. | |
| „ 2 - | ·03 „ | Occasional rain in morning. |
| „ 3 - | ·02 „ | „ „ and afternoon. |
| „ 4 to 8 | ·00 „ | |
| „ 9 - | ·02 „ | Showery in evening. |
| „ 10 to 21 | ·00 „ | |
| „ 22 - | ·03 „ | Shower of rain in afternoon. |
| „ 23 - | ·00 „ | |
| „ 24 - | ·04 „ | |
| „ 25 - | ·07 „ | Showery. |
| „ 26 - | ·07 „ | „ |
| „ 27 & 28 | ·00 „ | |
| „ 29 - | ·01 „ | Showery in afternoon. |
| „ 30 - | ·01 „ | Midday showery. |
| „ 31 - | ·00 „ | |
| August 1 & 2 | ·00 „ | |
| „ 3 - | ·23 „ | Slight rain in early morning; thunderstorm with rain before noon. |
| „ 4 - | 1·23 „ | Fine till noon; thunderstorms. |
| „ 5 - | ·39 „ | Showery in early morning; fine till evening; violent rain and lightning at night. |
| „ 6 - | ·14 „ | Rain with lightning in early morning; slight shower at night. |
| „ 7 to 9 | ·00 „ | |
| „ 10 - | ·46 „ | Overcast generally; frequent rain. |
| „ 11 - | ·00 „ | |
| „ 12 - | ·16 „ | Variable; showery; lightning; and thunder in the afternoon. |
| „ 13 - | ·12 „ | Overcast generally. |
| „ 14 - | ·23 „ | Rain fell heavily in early morning hours; generally fine after; shower of rain in evening |
| „ 15 - | ·11 „ | Fine and partially cloudy till evening; overcast afterwards. |
| „ 16 - | ·45 „ | Variable; frequent showers. |
| „ 17 - | ·01 „ | A light shower of rain fell about 6 p.m. otherwise fine. |
| „ 18 to 21 | ·00 „ | |
| „ 22 - | ·10 „ | Rain fell at night. |
| „ 23 - | ·83 „ | Frequent heavy showers of rain accompanied by thunder till evening. |
| „ 24 - | ·28 „ | Frequent heavy showers of rain with lightning and thunder. |
| „ 25 - | ·01 „ | A little rain fell in early morning. |
| „ 26 - | ·00 „ | |
| „ 27 - | ·08 „ | Cloudy and showery in morning. |
| „ 28 - | ·00 „ | |
| „ 29 - | ·32 „ | Cloudy; frequent showers of rain with thunder. |
| „ 30 - | ·42 „ | A gale of wind in morning; variable and showery with lightning and thunder during day. |
| „ 31 - | ·32 „ | Showers of rain; thunder in afternoon. |
| Sept. 1 to 7 | ·00 „ | |
| „ 8 - | ·01 „ | Fine till afternoon; overcast, with occasional thin rain afterwards. |
| „ 9 to 11 | ·00 „ | |
| „ 12 - | ·01 „ | A shower fell in afternoon. |
| „ 13 & 14 | ·00 „ | |
| „ 15 - | ·12 „ | Fine day; overcast with heavy rain at night. |
| „ 16 & 17 | ·00 „ | |
| „ 18 - | ·23 „ | Frequent rain till afternoon. |
| „ 19 - | ·00 „ | |
| „ 20 - | ·14 „ | Heavy rain in early morning; cloudy all day; sharp shower of rain and hail fell in afternoon; cloudless at night. |
| „ 21 - | ·00 „ | |
| „ 22 - | ·01 „ | Slight rain in morning; then rain in evening. |
| „ 23 - | ·13 „ | Rain in early morning; fine during day; evening cloudless, heavy dew. |
| „ 24 - | ·00 „ | |
| „ 25 - | ·05 „ | Occasional thin rain. |
| „ 26 to 29 | ·00 „ | |
| „ 30 - | ·12 „ | Rain fell in early morning hours; fine till afternoon; overcast afterwards. |
| Oct. 1 - | ·01 „ | Showery at night. |
| „ 2 to 5 | ·00 „ | |
| „ 6 - | ·04 „ | Rain fell in the evening. |
| „ 7 - | ·20 „ | Rain fell heavy in early morning hours; fine throughout day. |
| „ 8 - | ·06 „ | Rain fell in early morning hours; fine during day. |
| „ 9 - | ·07 „ | Showery and windy. |
| „ 10 - | ·17 „ | Showery till afternoon; fine afterwards. |
| „ 11 to 21 | ·00 „ | |
| „ 22 - | ·20 „ | Overcast with heavy rain in morning; shower of hail and rain in afternoon. |
| „ 23 - | ·01 „ | Showery in afternoon. |
| „ 24 - | ·32 „ | Overcast with rain throughout morning; fine in afternoon and evening. |
| „ 25 - | ·00 „ | |
| „ 26 - | ·45 „ | Cloudy and showery till evening. |
| „ 27 - | ·00 „ | |
| „ 28 - | ·02 „ | Occasional showers of rain and hail. |
| „ 29 - | ·00 „ | |
| „ 30 - | ·08 „ | Snow and rain fell in the morning |
| „ 31 - | ·03 „ | Overcast with rain in evening. |
| Nov. 1 - | ·01 „ | Overcast with rain in the morning; fine afternoon. |
| „ 2 to 7 | ·00 „ | |
| „ 8 - | ·10 „ | Showery. |
| „ 9 - | ·00 „ | |
| „ 10 - | ·79 „ | Overcast with frequent heavy rain till evening; fine night. |
| „ 11 - | ·04 „ | Shower of hail and granular snow fell shortly before 2 p.m.; thin rain at night. |
| „ 12 - | ·00 „ | |
| „ 13 - | ·03 „ | Occasional rain. |
| „ 14 - | ·44 „ | Frequent rain. |

App. A.H.

Rainfall and Weather Observations for the Years 1878 and 1879—(*continued*).

| 1878. | Rainfall. | Remarks. |
|---|---|---|
| Nov. 15 | ·36 inch. | Frequent rain. |
| ,, 16 | ·08 ,, | Rain fell in early morning hours. |
| ,, 17 | ·10 ,, | Showery. |
| ,, 18 | ·02 ,, | Rain fell in early morning hours. |
| ,, 19 to 23 | ·00 ,, | |
| ,, 24 | ·18 ,, | Showery. |
| ,, 25 | ·01 ,, | ,, in early morning. |
| ,, 26 | ·18 ,, | Frequent rain. |
| ,, 27 | ·69 ,, | Heavy rain. |
| ,, 28 | ·47 ,, | Frequent rain. |
| ,, 29 & 30 | ·00 ,, | |
| Dec. 1 | ·07 ,, | Overcast; occasional rain. |
| ,, 2 | ·00 ,, | |
| ,, 3 | ·01 ,, | Overcast, with a little snow in morning, with thin rain in the afternoon. |
| ,, 4 | ·00 ,, | |
| ,, 5 | ·01 ,, | Fog; thin rain in afternoon and evening. |
| ,, 6 | ·13 ,, | Heavy fall of snow at night. |
| ,, 7 | ·01 ,, | Slight fall of snow and sleet at night. |
| ,, 8 to 14 | ·00 ,, | |
| ,, 15 | ·01 ,, | Hoar frost in morning; snow fell in afternoon. |
| ,, 16 | ·06 ,, | Overcast; fog, rain, sleet and snow fell in afternoon and evening. |
| ,, 17 | ·00 ,, | |
| ,, 18 | ·02 ,, | Rain fell between 9 a.m. and noon. |
| ,, 19 to 21 | ·00 ,, | |
| ,, 22 | ·14 ,, | Foggy; snow fell frequently till afternoon. |
| ,, 23 & 24 | ·00 ,, | |
| ,, 25 | ·10 ,, | Snow and sleet in afternoon and evening. |
| ,, 26 | ·12 ,, | Rain; a very rapid thaw. |
| ,, 27 | ·13 ,, | Occasional rain. |
| ,, 28 | ·01 ,, | A little rain fell in early morning hours. |
| ,, 29 | ·10 ,, | Partially cloudy till evening; overcast, with rain at night. |
| ,, 30 | ·11 ,, | Cloudy, rain. |
| ,, 31 | ·13 ,, | Frequent showers of rain in afternoon and evening. |
| 1879. | | |
| Jan. 1 | ·78 ,, | Overcast generally; heavy rain in afternoon; sleet and snow at night. |
| ,, 2 | ·26 ,, | Snow fell during the morning. |
| ,, 3 | ·65 ,, | Heavy showers of rain in morning. |
| ,, 4 to 8 | ·00 ,, | |
| ,, 9 | ·02 ,, | Snow fell occasionally. |
| ,, 10 | ·00 ,, | |
| ,, 11 | ·01 ,, | Snow fell in morning; much ice in river. |
| ,, 12 | ·01 ,, | Fine till evening, then cloudy; rain fell after 11 p.m. |
| ,, 13 | ·03 ,, | Occasional rain in morning; a rapid thaw. |
| ,, 14 | ·21 ,, | Frequent rain. |
| ,, 15 | ·04 ,, | Showers of rain and hail in afternoon. |
| ,, 16 & 17 | ·00 ,, | |
| ,, 18 | ·56 ,, | Overcast, snow fell the greater part of the day. |
| ,, 19 to 23 | ·00 ,, | |
| ,, 24 | ·02 ,, | Occasional snow. |
| ,, 25 to 29 | ·00 ,, | |
| ,, 30 | ·01 ,, | Fine granular snow from 9 a.m. till 7 p.m. |
| ,, 31 | ·00 ,, | |
| Feb. 1 | ·04 ,, | Granular snow, sleet and frozen rain fell at night. |
| ,, 2 | ·08 ,, | Fog; rain fell throughout the afternoon and evening. |
| ,, 3 | ·49 ,, | Fog; rain fell till evening; sleet and snow at night. |
| ,, 4 | ·00 ,, | |
| ,, 5 | ·08 ,, | Occasional rain fell in afternoon and evening. |
| ,, 6 | ·00 ,, | |
| ,, 7 | ·18 ,, | Occasional showers of rain. |
| ,, 8 | ·02 ,, | Fine till evening; showery at night. |
| ,, 9 | ·30 ,, | Rain fell frequently. |
| ,, 10 | ·71 ,, | Overcast; heavy rain. |
| ,, 11 | ·09 ,, | Occasional rain. |
| ,, 12 | ·03 ,, | Cloudy; the sun shone occasionally between 9 a.m. and noon. |
| ,, 13 | ·08 ,, | Overcast; showery. |
| ,, 14 | ·08 ,, | ,, generally; rain fell in morning. |
| ,, 15 | ·00 ,, | |
| ,, 16 | ·23 ,, | Overcast generally and showery till evening; fine at night. |
| ,, 17 | ·09 ,, | Generally cloudy and showery till evening; fine at night. |
| ,, 18 | ·08 ,, | Generally cloudy, occasional showers of rain and snow. |
| ,, 19 | ·08 ,, | Sleet fell in early morning; fine till evening; rain and sleet at night. |
| ,, 20 | ·18 ,, | Rain and snow fell in early morning; heavy fall of snow shortly before 4 p.m. |
| ,, 21 | ·75 ,, | Very heavy fall of snow between 5 and 9 a.m.; depth about 8 inches. |
| ,, 22 | ·00 ,, | |
| ,, 23 | ·02 ,, | Snow fell in afternoon and evening. |
| ,, 24 to 26 | ·00 ,, | |
| ,, 27 | ·05 ,, | A little snow fell in morning; thin rain in afternoon and evening. |
| ,, 28 | ·15 ,, | Rain fell at night. |
| March 1 | ·03 ,, | Rain fell in early morning hours; thaw. |
| ,, 2 | ·00 ,, | |
| ,, 3 | ·05 ,, | Overcast from 11 a.m. with rain till 2 p.m. |
| ,, 4 & 5 | ·00 ,, | |
| ,, 6 | ·03 ,, | Rain in early morning. |
| ,, 7 to 10 | ·00 ,, | |
| ,, 11 | ·10 ,, | Showery all morning. |
| ,, 12 & 13 | ·00 ,, | |
| ,, 14 | ·04 ,, | Snow and rain fell generally. |
| ,, 15 | ·05 ,, | Rain fell in early morning hours. |
| ,, 16 | ·01 ,, | Occasional rain in morning. |
| ,, 17 & 18 | ·00 ,, | |
| ,, 19 | ·02 ,, | |
| ,, 20 & 21 | ·00 ,, | |

Rainfall and Weather Observations for the Years 1878 and 1879—(*continued*).

| 1879. | Rainfall. | Remarks. |
|---|---|---|
| March 22 | ·01 inch | A little rain and snow in early morning hours; little fine rain in afternoon. |
| ,, 23 & 24 | ·00 ,, | |
| ,, 25 | ·08 ,, | Overcast; frequent snow. |
| ,, 26 | ·05 ,, | Snow, sleet and rain. |
| ,, 27 & 28 | ·00 ,, | |
| ,, 29 | ·04 ,, | Variable, showery; hail fell with rain for a short time at 3 p.m. |
| ,, 30 | ·03 ,, | Showery in afternoon. |
| ,, 31 | ·06 ,, | Rain fell in early morning. |
| April 1 & 2 | ·00 ,, | |
| ,, 3 | ·08 ,, | Heavy showers of rain and hail with thunder and lightning in afternoon. |
| ,, 4 | ·00 ,, | |
| ,, 5 | ·05 ,, | Showery. |
| ,, 6 | ·10 ,, | Frequent rain. |
| ,, 7 | ·26 ,, | Showery. |
| ,, 8 | ·00 ,, | |
| ,, 9 | ·27 ,, | Rain fell at night. |
| ,, 10 | ·24 ,, | Frequent rain. |
| ,, 11 | ·00 ,, | |
| ,, 12 | ·18 ,, | Continued snow and sleet in afternoon and evening. |
| ,, 13 | ·08 ,, | Rain fell in morning. |
| ,, 14 | ·11 ,, | Rain and snow in afternoon and evening. |
| ,, 15 | ·03 ,, | Showery. |
| ,, 16 | ·33 ,, | Rain and snow fell in morning, and frequent showers of rain till afternoon. |
| ,, 17 | ·07 ,, | Showery. |
| ,, 18 & 19 | ·00 ,, | |
| ,, 20 | ·46 ,, | Frequent rain. |
| ,, 21 & 22 | ·00 ,, | |
| ,, 23 | ·15 ,, | Occasional rain. |
| ,, 24 | ·00 ,, | |
| ,, 25 | ·11 ,, | Showers of rain fell afternoon. |
| ,, 26 | ·00 ,, | |
| ,, 27 | ·07 ,, | Variable till afternoon, with occasional showers of rain and hail. |
| ,, 28 to 30 | ·00 ,, | |
| May 1 | ·19 ,, | Variable, with frequent showers of mingled rain and snow till evening. |
| ,, 2 to 5 | ·00 ,, | |
| ,, 6 | ·18 ,, | Rain fell between 6 a.m. and 10 a.m. |
| ,, 7 to 10 | ·00 ,, | |
| ,, 11 | ·07 ,, | Fine in early morning; showery afterwards. |
| ,, 12 | ·00 ,, | |
| ,, 13 | ·02 ,, | A little rain fell in evening. |
| ,, 14 | ·04 ,, | Showery; thunder heard in afternoon. |
| ,, 15 | ·28 ,, | Frequent rain. |
| ,, 16 | ·00 ,, | |
| ,, 17 | ·01 ,, | Rain fell at night. |
| ,, 18 | ·09 ,, | Frequent showers in morning. |
| ,, 19 to 22 | ·00 ,, | |
| ,, 23 | ·26 ,, | Frequent rain. |
| ,, 24 | ·00 ,, | |
| ,, 25 | ·23 ,, | Rain fell in morning. |
| ,, 26 | ·05 ,, | Showery. |
| ,, 27 | ·22 ,, | Frequent showers of rain. |
| ,, 28 | ·94 ,, | Rain fell in early morning and at night, with thunder and lightning. |
| ,, 29 | ·77 ,, | Very heavy rain in early morning, with thunder and lightning. |
| ,, 30 | ·00 ,, | |
| ,, 31 | ·01 ,, | Showery in afternoon. |
| June 1 | ·19 ,, | Showery. |
| ,, 2 | ·32 ,, | Frequent rain. |
| ,, 3 | ·37 ,, | Showery. |
| ,, 4 | ·01 ,, | A little rain fell in the afternoon. |
| ,, 5 | ·01 ,, | Occasional rain at night. |
| ,, 6 | ·21 ,, | Heavy rain early in morning. |
| ,, 7 | ·60 ,, | ,, ,, mostly between 5 and 9 p.m. |
| ,, 8 | ·06 ,, | Showery. |
| ,, 9 | ·01 ,, | Showery till evening. |
| ,, 10 | ·00 ,, | |
| ,, 11 | ·21 ,, | Frequent rain till evening. |
| ,, 12 | ·04 ,, | Showery. |
| ,, 13 & 14 | ·00 ,, | |
| ,, 15 | ·27 ,, | Occasional rain till evening. |
| ,, 16 | ·14 ,, | Showery in morning. |
| ,, 17 & 18 | ·00 ,, | |
| ,, 19 | ·01 ,, | Rain fell after 11 p.m. |
| ,, 20 | ·14 ,, | Rain fell frequently in early morning. |
| ,, 21 | ·26 ,, | ,, ,, ,, fine afternoon. |
| ,, 22 & 23 | ·00 ,, | |
| ,, 24 | ·48 ,, | Frequent showers of rain; thunderstorm with violent hailstorm. |
| ,, 25 | ·85 ,, | Frequent showers of rain; heavy from 3 to noon; fine after 2 p.m. |
| ,, 26 | ·09 ,, | Occasional showers. |
| ,, 27 to 29 | ·00 ,, | |
| ,, 30 | ·01 ,, | Rain fell after 11 p.m. |
| July 1 | ·50 ,, | Frequent rain till afternoon. |
| ,, 2 | ·38 ,, | ,, showers of rain in afternoon, with thunder and lightning. |
| ,, 3 | ·63 ,, | Rain till evening. |
| ,, 4 | ·11 ,, | Showery. |
| ,, 5 | ·10 ,, | ,, |
| ,, 6 | ·09 ,, | Fine in morning; showers afterwards. |
| ,, 7 | ·14 ,, | Rain fell part of the morning. |
| ,, 8 | ·04 ,, | Showery. |
| ,, 9 | ·23 ,, | ,, |
| ,, 10 | ·01 ,, | A little rain. |
| ,, 11 | ·00 ,, | |
| ,, 12 | ·07 ,, | Fine in morning; showery afterwards. |
| ,, 13 | ·07 ,, | Showery. |
| ,, 14 | ·16 ,, | Rain fell in evening. |
| ,, 15 to 19 | ·00 ,, | |
| ,, 20 | ·70 ,, | Frequent rain; thunder in afternoon. |
| ,, 21 | ·33 ,, | ,, ,, |
| ,, 22 | ·03 ,, | Showery. |
| ,, 23 | ·00 ,, | |

Rainfall and Weather Observations for the Years 1878 and 1879—(*continued*).

| 1879. | Rainfall. | Remarks. |
|---|---|---|
| July 24 - | ·02 inch. | Showery in morning. |
| „ 25 - | ·00 „ | |
| „ 26 - | ·01 „ | A few light showers of rain. |
| „ 27 to 30 | ·00 „ | |
| „ 31 - | ·10 „ | Continual rain till afternoon. |
| August 1 - | ·16 „ | Continual rain in early morning. |
| „ 2 - | ·00 „ | |
| „ 3 - | ·09 „ | Slight thunderstorm a.m. |
| „ 4 - | ·01 „ | Showery in morning. |
| „ 5 - | ·09 „ | Fine, generally cloudy. |
| „ 6 - | ·21 „ | Showery; thunder about noon. |
| „ 7 - | ·10 „ | „ in afternoon an evening. |
| „ 8 - | ·01 „ | A little rain at night. |
| „ 9 to 15 | ·00 „ | |
| „ 16 - | ·03 „ | Showery. |
| „ 17 - | ·51 „ | Frequent rain. |
| „ 18 - | ·19 „ | „ „ in morning, |
| „ 19 - | ·38 „ | „ „ |
| „ 20 - | ·56 „ | Heavy rain all morning; some showers after. |
| „ 21 - | ·20 „ | Frequent showers; in afternoon rain with thunder. |
| „ 22 - | ·02 „ | A shower fell about 10 a.m. |
| „ 23 - | 1·17 „ | Heavy rain till afternoon; showers in evening. |
| „ 24 - | ·00 „ | |
| „ 25 - | ·16 „ | Frequent showers in morning. |
| „ 26 - | ·39 „ | Fine morning; showery after. |
| „ 27 - | ·22 „ | Rain fell frequently. |
| „ 28 - | ·48 „ | Heavy rain from 6 a.m. to 2 p.m. |
| „ 29 - | ·16 „ | Showery in afternoon and evening. |
| „ 30 & 31 | ·00 „ | |
| Sept. 1 to 4 | ·00 „ | |
| „ 5 - | ·01 „ | A little rain fell in the morning. |
| „ 6 - | ·01 „ | Slight rain about 1 p.m. |
| „ 7 - | ·01 „ | Showery in afternoon. |
| „ 8 - | ·06 „ | Heavy shower fell between 10 and 10.30 a.m. |
| „ 9 - | ·17 „ | Showery. |
| „ 10 & 11 | ·00 „ | |
| „ 12 - | ·12 „ | Showery at night. |
| „ 13 - | ·36 „ | Rain in afternoon. |
| „ 14 - | ·19 „ | Rain in morning. |
| „ 15 & 16 | ·00 „ | |
| „ 17 - | ·07 „ | Occasional rain. |
| „ 18 - | ·03 „ | A little rain. |
| „ 19 to 22 | ·00 „ | |
| „ 23 - | ·75 „ | Frequent rain. |
| „ 24 - | ·71 „ | Heavy rain in morning; showery after. |
| „ 25 to 27 | ·00 „ | |
| „ 28 - | ·19 „ | Heavy rain at night. |
| „ 29 - | ·16 „ | Heavy rain in early morning hours. |
| „ 30 - | ·00 „ | |
| Oct. 1 - | ·20 „ | Heavy rain in morning. |
| „ 2 - | ·02 „ | Showery between 9 a.m. and 1 p.m. |
| „ 3 to 13 | ·00 „ | |
| „ 14 - | ·01 „ | A little rain fell at night. |
| „ 15 to 17 | ·00 „ | |
| „ 18 - | ·01 „ | Little rain at night. |
| „ 19 - | ·16 „ | Frequent rain. |
| „ 20 - | ·01 „ | A shower fell between 1 p.m. and 2 p.m. |
| „ 21 - | ·00 „ | |
| „ 22 - | ·02 „ | Average for 24 hours:—Foggy in morning; overcast, with occasional *misty rain* during day. |
| „ 23 - | ·01 „ | Thin rain at night. |
| „ 24 - | ·07 „ | Occasional rain in afternoon and evening. |
| „ 25 - | ·21 „ | Showery in morning. |
| „ 26 - | ·01 „ | Showery from 4 p.m. till evening. |
| „ 27 & 28 | ·00 „ | |
| „ 29 - | ·04 „ | Thin rain. |
| „ 30 & 31 | ·00 „ | |
| Nov. 1 - | ·01 „ | Occasional thin rain. |
| „ 2 - | ·00 „ | |
| „ 3 - | ·01 „ | Occasional thin rain. |
| „ 4 to 9 | ·00 „ | |
| „ 10 - | ·01 „ | Occasional thin rain. |
| „ 11 - | ·01 „ | Shower of rain fell about 5 p.m. |
| „ 12 to 18 | ·00 „ | |
| „ 19 - | ·01 „ | Thin rain in morning. |
| „ 20 - | ·15 „ | Frequent snow. |
| „ 21 - | ·32 „ | „ „ |
| „ 22 - | ·15 „ | Snow in morning. |
| „ 23 - | ·00 „ | |
| „ 24 - | ·12 „ | Fog in morning, rain at night. |
| „ 25 - | ·04 „ | After 4 p.m. rain, frozen rain and snow occasionally fell. |
| „ 26 - | ·02 „ | Occasional snow. |
| „ 27 - | ·01 „ | Little rain and snow at night. |
| „ 28 to 30 | ·00 „ | |
| Dec. 1 - | ·04 „ | Snow fell frequently. |
| „ 2 to 4 | ·00 „ | |
| „ 5 - | ·08 „ | Fog in morning; snow fell now and then in afternoon and evening, heavily at night. |
| „ 6 & 7 | ·00 „ | |
| „ 8 - | ·03 „ | Snow fell in morning. |
| „ 9 - | ·01 „ | Snow and sleet at night. |
| „ 10 - | ·01 „ | Little thin rain in forenoon. |
| „ 11 to 18 | ·00 „ | |
| „ 19 - | ·01 „ | Thin rain fell in afternoon and evening. |
| „ 20 & 21 | ·00 „ | |
| „ 22 - | ·03 „ | Thin rain till afternoon. |
| „ 23 to 27 | ·00 „ | |
| „ 28 - | ·03 „ | Thin rain in morning. |
| „ 29 - | ·00 „ | |
| „ 30 - | ·21 „ | Frequent heavy showers of rain at times mingled with hail and between 1 and 1.30 p.m. lightning and thunder. |
| „ 31 - | ·19 „ | Frequent rain. |
| 1880. | | |
| Jan. 1 - | ·01 „ | Occasional rain. |
| „ 2 to 6 | ·00 „ | A little rain between 9 and 10 a.m. on the 2nd. |

TABLE B.

App. A.H.

LONDON SEWAGE.

SECTION I.—*Fair Weather Samples.*

[Samples marked with one * were analysed by Messrs. HOFFMANN and WITT. Those with † by Mr. KEATES. The unmarked samples by Dr. FRANKLAND.]

| Date. | Remarks. | Name of Sewer. | Suspended Matter in Grains per Gallon. | | |
|---|---|---|---|---|---|
| | | | Mineral. | Organic | Total. |
| 1857. | | | | | |
| May 13 | - - - | Savoy Street - | 10·58 | 8·35 | 18·93* |
| March 18 | - - - | King's Scholar's Pond. | 14·59 | 12·04 | 26·63* |
| April 8 | Rain previous afternoon. | „ „ | *25·91* | *15·19* | *41·10** |
| May 16 | No rain since 12th. | Northumberland Street. | *16·09* | *36·40* | *52·49** |
| „ 28 | „ „ „ | „ „ | *21·48* | *35·42* | *56·90** |
| June 13 | No rain since 11th. | „ „ | 14·44 | 25·04 | 39·48* |
| „ 11 | Very slight rain, not measureable. | Savoy Street - | 19·23 | 13·55 | 32·78* |
| 1869. | | | | | |
| Feb. 23 | - - - | Northumberland Street. | 10·84 | 13·19 | 24·03 |
| „ 27 | - - - | „ „ | 13·80 | 11·26 | 25·06 |
| March 5 | - - - | „ „ | 12·40 | 15·09 | 27·49 |
| „ 9 | - - - | „ „ | 12·07 | 12·12 | 24·19 |
| „ 13 | ·01 rain evening | „ „ | 7·95 | 13·47 | 21·42 |
| „ 23 | - - - | „ „ | 11·68 | 17·47 | 29·15 |
| „ 30 | - - - | „ „ | 12·80 | 21·39 | 34·19 |
| April 10 | - - - | „ „ | 11·84 | 16·91 | 28·75 |
| „ 14 | No rain previous day. | „ | *36·74* | *28·90* | *65·64* |
| „ 20 | „ „ „ | „ „ | 22·68 | 20·08 | 42·76 |
| „ 28 | - - - | „ „ | 16·72 | 11·56 | 28·28 |
| May 30 | - - - | „ „ | 13·72 | 11·17 | 24·89 |
| May 12 | Rain previous night. | „ „ | *47·26* | *14·84* | *62·10* |
| June 23 | - - - | Northern Outfall | 12·94 | 19·46 | 32·40 |
| Dec. 20 | - - - | Northumberland Street. | 17·01 | 11·69 | 28·70 |
| 1870. | | | | | |
| May 23 | - - - | „ „ | 7·53 | 12·91 | 20·44 |
| June 7 | - - - | „ „ | *26·74* | *28·73* | *55·5#* |
| 1872. | | | | | |
| March 5 | - - - | „ „ | 11·54 | 12·54 | 24·08 |
| 1878. | | | | | |
| Jan. 8 | Sample taken at midnight. | Southern Outfall | 8·86 | 14·04 | 22·90† |
| „ „ | Sample taken at midday. | „ „ | 3·93 | 4·21 | 8·14† |
| „ 10 | 3 a.m. - - | „ „ | 5·15 | 12·70 | 17·85† |
| „ „ | „ „ - - | Northern „ | 12·00 | 9·10 | 21·10† |
| „ „ | 3 p.m. - - | „ „ | 14·75 | 18·60 | 33·35† |
| „ „ | „ „ - - | Southern „ | 6·80 | 16·20 | 24·00† |
| „ 11 | 3 a.m. - - | „ „ | 7·50 | 14·70 | 22·20† |
| „ „ | „ „ - - | Northern „ | 5·50 | 16·65 | 22·15† |
| „ „ | 3 p.m. - - | „ „ | 12·50 | 27·50 | 40·00† |
| „ „ | „ „ - - | Southern „ | 6·00 | 15·70 | 21·70† |
| „ 12 | 3 a.m. - - | „ „ | 5·70 | 10·20 | 15·90† |
| „ „ | „ „ - - | Northern „ | 5·70 | 11·10 | 16·80† |
| „ „ | 3 p.m. - - | „ „ | 14·20 | 20·60 | 34·80† |
| „ „ | „ „ - - | Southern „ | 3·50 | 4·85 | 8·35† |
| „ 13 | 3 a.m. - - | „ „ | 8·50 | 11·00 | 19·50† |
| „ „ | „ „ - - | Northern „ | 5·70 | 10·00 | 15·70† |
| „ „ | 3 p.m. - - | „ „ | 10·50 | 15·50 | 26·00† |
| „ „ | „ „ - - | Southern „ | 7·35 | 10·00 | 17·35† |
| „ 14 | 3 a.m. - - | „ „ | 3·95 | 10·55 | 14·50† |
| „ „ | „ „ - - | Northern „ | 3·45 | 6·35 | 9·80† |
| „ „ | 3 p.m. - - | „ „ | 14·40 | 22·10 | 36·50† |
| „ „ | „ „ - - | Southern „ | 5·70 | 9·60 | 15·30† |
| „ 15 | 3 a.m. - - | „ „ | 8·70 | 13·35 | 22·05† |
| „ „ | 3 p.m. - - | „ „ | 8·50 | 12·10 | 20·60† |
| „ 16 | „ - - | „ „ | 10·20 | 16·30 | 26·50† |
| „ 17 | 3 a.m. - - | „ „ | 10·85 | 27·00 | 37·85† |
| „ „ | 3 p.m. - - | „ „ | 7·35 | 12·35 | 19·70† |
| „ 18 | „ „ - - | „ „ | 6·50 | 11·30 | 17·80† |
| „ 19 | 3 a.m. - - | „ „ | 9·50 | 23·00 | 32·50† |
| „ 20 | „ „ - - | Northern „ | 10·00 | 16·30 | 26·30† |
| „ „ | 3 p.m. - - | „ „ | 9·00 | 15·20 | 24·20† |
| Dec. 9 | Midnight - - | „ „ | 6·37 | 14·63 | 21·00† |
| „ 10 | Noon - - | „ „ | 3·03 | 6·48 | 9·51† |
| „ „ | 3 p.m. - - | Southern „ | 5·28 | 10·96 | 16·24† |
| „ „ | Midnight - - | Northern „ | 6·51 | 15·29 | 21·80† |
| „ 11 | Noon - - | „ „ | 3·96 | 8·92 | 12·88† |
| „ „ | 3 a.m. - - | Southern „ | 7·83 | 34·34 | 42·67† |
| „ „ | 3 p.m. - - | „ „ | 5·07 | 11·64 | 16·71† |
| „ „ | Midnight - - | Northern „ | 6·18 | 13·94 | 20·12† |
| „ 12 | 3 a.m. - - | Southern „ | 7·77 | 14·73 | 22·50† |
| „ „ | Noon - - | Northern „ | 9·30 | 10·09 | 19·39† |

Samples containing more than 42·91 grains of Suspended Matter per gallon are printed in italics in this Section of the Table. Also the Sample collected on April 8th, 1857, on account of the rain on the previous afternoon.

App. A.H

LONDON SEWAGE—(*continued*).

| Date. | Remarks. | Name of Sewer. | Suspended Matter in Grains per Gallon. | | |
|---|---|---|---|---|---|
| | | | Mineral. | Organic. | Total. |
| 1878. | | | | | |
| Dec. 12 | 3 p.m. - | Southern Outfall | 5·60 | 11·81 | 17·41† |
| „ 13 | 3 a.m. - - | „ „ | 4·56 | 9·95 | 14·51† |
| „ 17 | Noon - - | Northern „ | 9·28 | 8·22 | 17·50† |
| „ „ | Midnight - | „ „ | 12·85 | 15·58 | 28·43† |
| „ 18 | Noon - | „ „ | 3·77 | 6·86 | 10·63† |
| „ 19 | „ - - | „ „ | 9·14 | 9·60 | 18·74† |
| „ „ | Midnight - | „ „ | 11·40 | 17·56 | 28·96† |
| 1879. | | | | | |
| Dec. 17 | 3.30 p.m. - | „ „ | 8·96 | 11·96 | 20·92 |
| „ 18 | 2.45 „ - - | „ „ | 12·32 | 16·19 | 29·01 |
| „ 20 | 2.30 „ - - | „ „ | 5·88 | 7·84 | 13·72 |
| „ 23 | 2.45 „ - - | „ „ | 9·58 | 10·41 | 19·99 |
| „ 24 | 2.30 „ - - | „ „ | 12·66 | 21·64 | 34·30 |

LONDON SEWAGE—*continued*

| Date. | Remarks. | Name of Sewer. | Suspended Matter in Grains per Gallon. | | |
|---|---|---|---|---|---|
| | | | Mineral. | Organic. | Total. |
| 1880. | | | | | |
| Jan. 2 | 2.0 p.m. - - | Northern Outfall | 7·60 | 9·45 | 17·05 |
| „ 3 | 2.0 „ - | „ „ | 7·75 | 11·25 | 19·00 |
| „ 5 | 3.30 „ - - | „ „ | 7·50 | 14·42 | 21·92† |
| „ 6 | 4.0 „ - - | „ „ | 10·22 | 15·38 | 25·60† |
| | | 76 Samples | 707·47 | 1058·08 | 1765·55 |
| | | Average | 9·31 | 13·92 | 23·23 |
| | | Percentage quantities - | 40·08 | 59·92 | 100·00 |

SECTION II.—Suspended Matter with ·01 to ·03 inch Rainfall.

| Date. | Rainfall. | Weather and Remarks. | Name of Sewer. | Grains per Gallon. | | |
|---|---|---|---|---|---|---|
| | | | | Mineral. | Organic. | TOTAL. |
| 1857. April 10 | ·02 inch. | Lightning and thunder - | Fleet Street, 8·45 p.m. - | *9·18* | *6·20* | *15·38** |
| 1869. March 13 | ·01 „ | Rain in the evening - - | Northumberland Street - | *7·95* | *13·47* | *21·42* |
| „ April 7 | ·01 „ | „ early morning - | „ - | 35·08 | 26·60 | 61·68 |
| 1878. Jan. 15 | ·02 „ | Sample collected at 3 a.m. on 16th. | Southern outfall - - | 9·55 | 37·20 | 46·75† |
| „ Dec. 18 | ·02 „ | Rain between 9 a.m. and noon - | Northern outfall sample at 12 p.m. | 13·40 | 22·67 | 36·07† |
| 1869. May 7 | ·03 „ | Occasional rain - - | Northumberland Street - | 22·99 | 14·22 | 37·21 |
| 1879. Oct. 22 | ·02 „ | Foggy in morning; overcast with occasional *misty* rain during day. | Southern outfall samples every 2 hours from noon to midnight. | 13·73 | 19·09 | 32·82† |
| „ Dec. 19 | ·01 „ | Thin rain, afternoon and evening. | Northern outfall sample at 2·45 p.m. | *6·91* | *8·24* | *15·15* |
| „ „ 22 | ·03 „ | Overcast, with fog and thin rain till afternoon; cloudless but very foggy afterwards. | 2·30 p.m. | *10·19* | *14·53* | *24·72* |
| 1880. Jan. 1 | ·01 „ | Occasional rain - - - | Northern outfall - - | *11·02* | *9·60* | *20·62†* |
| | | | 5 Samples | 94·75 | 119·78 | 214·53 |
| | | | Average - - | 18·95 | 23·96 | 42·91 |
| | | | Percentage quantities - - - | 44·16 | 55·84 | 100·00 |

Numbers whose totals are below 25 grains per gallon are printed in Italics from this section of the Table.

SECTION III.—Suspended Matter. Rainfall above ·03 and under ·1.

| | | | | | | |
|---|---|---|---|---|---|---|
| 1857 | March 19 | ·06 inch. | *Misty* rain fell frequently - | Fleet Street, 12·15 p.m. - - | *19·30* | *19·86* | *39·16** |
| 1869. | „ 19 | ·09 „ | Rain fell occasionally - - | Northumberland Street - | 58·86 | 31·16 | 90·02 |
| | | | | Percentage quantities - | 65·38 | 34·62 | 100·00 |

SECTION IV.—Suspended Matter. Rainfall ·10 inch and over.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1857. | April | 9 | ·13 inch. | Rain fell early in the morning - | Fleet Street, 11 a.m. - - | 110·54 | 35·46 | 146·00* |
| „ | „ | 9 | ·13 „ | „ „ „ „ - | King's Scholar's Pond, 10 a.m. - | 110·43 | 30·85 | 141·33* |
| | June | 20 | ·85 „ | Rain fell between 7 and 8 the previous evening, at 0·40 a.m.; 5 in. rain fell in 10 minutes. Severe thunderstorm in afternoon. | Savoy Street, 2·15 a.m. - - | | | 209·25* |
| 1869. | March | 2 | ·24 „ | Frequent rain and snow - | Northumberland Street - | 56·06 | 28·87 | 84·93 |
| „ | April | 3 | ·12 „ | Frequent rain - - | „ „ - - | *19·66* | *16·77* | *36·43* |
| „ | „ | 17 | ·33 „ | | „ „ - - | 57·46 | 18·79 | 76·25 |
| „ | „ | 23 | ·20 „ | Rain from 1 to 2·30 p.m., also heavily at night. | „ „ - - | 127·96 | 35·95 | 163·91 |
| „ | May | 4 | ·63 „ | Rain all day till 6 p.m. - | „ „ - - | 49·92 | 13·05 | 62·97 |
| 1871. | Jan. | 23 | ·19 „ | Rain fell frequently and ·22 in. previous night. | „ „ - - | 165·70 | 44·72 | 210·42 |
| 1879. | Dec. | 30 | ·21 „ | Thunderstorm between 1 and 1·30 p.m. Frequent heavy showers. | Northern Outfall, at 3.25 p.m. - | 77·42 | 41·98 | 119·40 |
| | | 31 | ·19 „ | Frequent rain - - - | „ „ at 3.15 p.m. - | *14·19* | *15·79* | *29·69* |
| | | | | | 8 and 9 Samples | 755·54 | 249·67 | 1,214·46 |
| | | | | | Average - - | 94·44 | 31·21 | 134·94 |
| | | | | | Percentage quantities | 75·16 | 24·84 | 100·00 |

Numbers below the average in the Second Section of this Table are printed in Italics in this Section.

## TABLE C.

RAINFALL and DISCHARGE of SUSPENDED MATTER and SEWAGE (LONDON) during the years 1878 and 1879

| 1878. Days. | Rainfall. | Grains of Dry Suspended Matter per Gallon. | Gallons of Sewage per day. | Tons of Dry Suspended Matter discharged. | Tons of Wet Suspended Matter discharged.* |
|---|---|---|---|---|---|
| 199 | 00 inch. | 23·23 | 130,000,000 | 38,325·41 | 114,976·23 |
| 32 | ·01 ,, | 42·91 | 144,131,000 | 12,621·76 | 37,865·28 |
| 17 | ·02 ,, | | 158,262,000 | 7,362·71 | 22,088·13 |
| 11 | ·03 ,, | | 172,393,000 | 5,178·49 | 15,568·47 |
| 4 | ·04 ,, | 90·02 | 186,524,000 | 4,283·36 | 12,850·08 |
| 4 | ·05 ,, | | 200,655,000 | 4,607·88 | 13,823·64 |
| 5 | ·06 ,, | | 214,786,000 | 6,165·50 | 18,496·50 |
| 8 | ·07 ,, | | 228,917,000 | 10,513·76 | 31,541·28 |
| 6 | ·08 ,, | | 243,048,000 | 8,372·10 | 25,116·30 |
| 1 | ·09 ,, | | 257,179,000 | 1,476·48 | 4,429·44 |
| 5 | ·10 ,, | | 271,310,000 | 11,674·25 | 35,022·75 |
| 4 | ·11 ,, | | 285,441,000 | 9,825·84 | 29,477·52 |
| 6 | ·12 ,, | | 299,572,000 | 15,468·42 | 46,405·26 |
| 6 | ·13 ,, | | 313,703,000 | 16,198·08 | 48,594·24 |
| 4 | ·14 ,, | | 327,834,000 | 11,285·16 | 33,855·48 |
| 3 | ·16 ,, | | 356,096,000 | 9,193·53 | 27,580·59 |
| 2 | ·17 ,, | | 370,227,000 | 6,372·24 | 19,116·72 |
| 2 | ·18 ,, | | 384,358,000 | 6,615·46 | 19,846·38 |
| 2 | ·19 ,, | | 398,489,000 | 6,858·68 | 20,576·04 |
| 4 | ·20 ,, | | 412,620,000 | 14,203·80 | 42,611·40 |
| 1 | ·21 ,, | | 426,751,000 | 3,672·56 | 11,017·68 |
| 2 | ·22 ,, | | 440,882,000 | 7,588·34 | 22,765·02 |
| 3 | ·23 ,, | | 455,031,000 | 11,747·34 | 35,242·02 |
| 1 | ·25 ,, | | 483,275,000 | 4,159·01 | 12,477·03 |
| 1 | ·26 ,, | | 497,406,000 | 4,280·61 | 12,841·83 |
| 1 | ·28 ,, | | 525,668,000 | 4,523·81 | 13,571·49 |
| 2 | ·30 ,, | | 553,930,000 | 9,534·10 | 28,602·30 |
| 1 | ·31 ,, | | 568,061,000 | 4,888·66 | 14,665·98 |
| 4 | ·32 ,, | | 582,192,000 | 20,041·08 | 60,123·24 |
| 1 | ·33 ,, | 134·94 | 596,323,000 | 5,131·88 | 15,395·64 |
| 1 | ·36 ,, | | 638,716,000 | 5,496·70 | 16,490·10 |
| 1 | ·38 ,, | | 666,978,000 | 5,739·92 | 17,219·76 |
| 3 | ·39 ,, | | 681,109,000 | 17,584·60 | 52,753·80 |
| 1 | ·40 ,, | | 695,240,000 | 5,983·14 | 17,949·42 |
| 1 | ·42 ,, | | 723,502,000 | 6,226·36 | 18,679·08 |
| 1 | ·43 ,, | | 737,633,000 | 6,347·97 | 19,043·91 |
| 1 | ·44 ,, | | 751,764,000 | 6,469·58 | 19,408·74 |
| 2 | ·45 ,, | | 765,895,000 | 13,182·38 | 39,547·14 |
| 1 | ·46 ,, | | 780,026,000 | 6,712·80 | 20,138·40 |
| 1 | ·47 ,, | | 794,157,000 | 6,834·41 | 20,503·23 |
| 1 | ·51 ,, | | 850,681,000 | 7,320·85 | 21,962·55 |
| 1 | ·61 ,, | | 991,991,000 | 8,536·94 | 25,610·82 |
| 1 | ·69 ,, | | 1,105,039,000 | 9,500·82 | 28,529·46 |
| 1 | ·79 ,, | | 1,246,349,000 | 10,725·91 | 32,177·73 |
| 1 | ·89 ,, | | 1,387,659,000 | 11,942·01 | 35,826·03 |
| 1 | ·98 ,, | | 1,514,838,000 | 13,036·49 | 39,109·47 |
| 1 | 1·05 ,, | | 1,613,755,000 | 13,887·76 | 41,663·28 |
| 1 | 1·23 ,, | | 1,868,113,000 | 16,076·73 | 48,230·19 |
| 1 | 1·52 ,, | | 2,277,912,000 | 19,603·41 | 58,810·23 |
| 1 | 2·51 ,, | | 3,676,881,000 | 31,642·75 | 94,928·25 |
| 365 | | | | 505,041·85 | 1,515,125·55 |

Tons of Wet Mud containing 60 % of Water - 1,262,604·62

* The numbers in this column are obtained by multiplying by three those in the previous column.

| 1879. Days. | Rainfall. | Grains of Dry suspended Matter per Gallon. | Gallons of Sewage per day. | Tons of Dry Suspended Matter discharged | Tons of Wet Suspended Matter discharged.* |
|---|---|---|---|---|---|
| 180 | ·00 inch. | 23·23 | 134,000,000 | 35,733·60 | 107,200·80 |
| 33 | ·01 ,, | 42·91 | 148,131,000 | 13,377·42 | 40,132·26 |
| 11 | ·02 ,, | | 162,262,000 | 4,884·21 | 14,562·63 |
| 12 | ·03 ,, | | 176,393,000 | 5,792·64 | 17,377·92 |
| 10 | ·04 ,, | 90·02 | 190,524,000 | 10,938·12 | 32,814·36 |
| 6 | ·05 ,, | | 204,655,000 | 7,049·63 | 21,148·89 |
| 3 | ·06 ,, | | 218,786,000 | 3,768·19 | 11,304·57 |
| 7 | ·07 ,, | | 232,917,000 | 9,360·35 | 28,081·05 |
| 10 | ·08 ,, | | 247,048,000 | 14,183·20 | 42,549·60 |
| 7 | ·09 ,, | | 261,179,000 | 10,496·13 | 31,488·39 |
| 5 | ·10 ,, | | 275,310,000 | 11,846·41 | 35,539·23 |
| 3 | ·11 ,, | | 289,441,000 | 7,472·67 | 22,418·01 |
| 2 | ·12 ,, | | 303,572,000 | 5,225·00 | 15,675·00 |
| 3 | ·14 ,, | | 331,834,000 | 8,567·16 | 25,701·48 |
| 4 | ·15 ,, | | 345,965,000 | 11,909·31 | 35,727·93 |
| 6 | ·16 ,, | | 360,096,000 | 18,593·63 | 55,780·89 |
| 1 | ·17 ,, | | 374,227,000 | 3,220·55 | 9,661·65 |
| 4 | ·18 ,, | | 388,358,000 | 13,368·03 | 40,105·89 |
| 6 | ·19 ,, | | 402,489,000 | 20,782·60 | 62,347·80 |
| 3 | ·20 ,, | | 416,620,000 | 10,756·13 | 32,268·39 |
| 6 | ·21 ,, | 134·94 | 430,751,000 | 22,241·92 | 66,725·76 |
| 1 | ·22 ,, | | 444,882,000 | 3,828·60 | 11,485·80 |
| 3 | ·23 ,, | | 459,013,000 | 11,850·61 | 35,551·83 |
| 1 | ·24 ,, | | 473,144,000 | 4,071·81 | 12,215·43 |
| 4 | ·26 ,, | | 501,406,000 | 17,260·13 | 51,780·39 |
| 2 | ·27 ,, | | 515,537,000 | 8,873·29 | 26,619·87 |
| 1 | ·28 ,, | | 529,668,000 | 4,558·25 | 13,674·75 |
| 1 | ·29 ,, | | 543,799,000 | 4,679·86 | 14,039·58 |
| 1 | ·30 ,, | | 557,930,000 | 5,801·47 | 14,404·41 |
| 2 | ·32 ,, | | 586,192,000 | 10,089·38 | 30,268·14 |
| 3 | ·33 ,, | | 600,323,000 | 15,498·90 | 46,496·70 |
| 1 | ·36 ,, | | 642,716,000 | 5,531·13 | 16,593·39 |
| 2 | ·37 inch | | 656,847,000 | 11,305·48 | 33,916·44 |
| 1 | ·38 ,, | | 670,978,000 | 5,774·35 | 17,323·05 |
| 1 | ·39 ,, | | 685,109,000 | 5,895·96 | 17,687·88 |
| 1 | ·46 ,, | | 784,026,000 | 6,747·22 | 20,241·66 |
| 2 | ·48 ,, | | 812,288,000 | 13,980·89 | 41,942·67 |
| 1 | ·50 ,, | | 840,550,000 | 7,233·66 | 21,700·98 |
| 1 | ·51 ,, | | 854,681,000 | 7,355·27 | 22,065·81 |
| 2 | ·56 ,, | | 925,336,000 | 15,926·64 | 47,779·92 |
| 1 | ·60 ,, | | 981,860,000 | 8,449·76 | 25,349·28 |
| 1 | ·63 ,, | 134·94 | 1,024,253,000 | 8,814·59 | 26,443·77 |
| 1 | ·65 ,, | | 1,052,515,000 | 9,057·80 | 27,173·40 |
| 1 | ·70 ,, | | 1,123,170,000 | 9,665·85 | 28,997·55 |
| 1 | ·71 ,, | | 1,137,301,000 | 9,787·46 | 29,362·38 |
| 2 | ·75 ,, | | 1,193,825,000 | 20,547·80 | 61,643·40 |
| 1 | ·77 ,, | | 1,222,087,000 | 10,517·12 | 31,551·36 |
| 1 | ·78 ,, | | 1,236,218,000 | 10,639·73 | 31,919·19 |
| 1 | ·85 ,, | | 1,335,135,000 | 11,489·99 | 34,469·97 |
| 1 | ·94 ,, | | 1,462,314,000 | 12,584·48 | 37,753·44 |
| 1 | 1·17 ,, | | 1,787,327,000 | 15,381·50 | 46,144·50 |
| 365 | | | | 541,765·48 | 1,625,296·44 |

Tons of Wet Mud containing 60% of Water - 1,354,413·70

* The numbers in this column are obtained by multiplying by three those in the previous column.

## TABLE D.

QUANTITY of DRY MUD discharged into the THAMES from the LONDON SEWERS during the Years 1878 and 1879.

1878.

| | Mineral. | Organic. | Total. |
|---|---|---|---|
| Tons of dry mud discharged into the Thames in fair weather. | 15,360·8 | 22,964·6 | 38,325·4 |
| Ditto with rainfall not exceeding ·05 in. | 11,116·8 | 14,057·2 | 25,174·0 |
| ,, ,, above ·03 but under ·1 in. | 23,157·0 | 12,262·1 | 35,419·1 |
| ,, ,, of ·1 inch and upwards. | 305,242·4 | 100,881·0 | 406,123·4 |
| Total dry mud discharged - | 354,877·0 | 150,164·9 | 505,041·9 |
| PERCENTAGE COMPOSITION OF MUD. | | | |
| In fair weather - - - - | 40·08 | 59·92 | 100·00 |
| With rain not exceeding ·03 inch - | 44·16 | 55·84 | 100·00 |
| ,, above ·03 inch but under ·1 in. | 65·38 | 34·62 | 100·00 |
| ,, of ·1 inch and upwards - | 75·16 | 24·84 | 100·00 |
| Average | 70·28 | 29·72 | 100·00 |

1879.

| | Mineral. | Organic. | Total. |
|---|---|---|---|
| Tons of dry mud discharged into the Thames in dry weather. | 14,322·0 | 21,411·6 | 35,733·6 |
| Ditto with rainfall not exceeding ·03 in. | 10,622·4 | 13,431·9 | 24,054·3 |
| ,, ,, above ·03 but under ·1 in. | 36,479·2 | 19,316·4 | 55,795·6 |
| ,, ,, of ·1 inch and upwards. | 320,318·4 | 105,863·6 | 426,182·0 |
| Total mud discharged - - | 381,742·0 | 160,023·5 | 541,765·5 |
| PERCENTAGE COMPOSITION OF MUD. | | | |
| In fair weather - - - - - | 40·08 | 59·92 | 100·00 |
| With rain not exceeding ·03 inch - | 44·16 | 55·84 | 100·00 |
| ,, above ·03 but under ·1 inch | 65·38 | 34·62 | 100·00 |
| ,, of ·1 inch and upwards - | 75·16 | 24·84 | 100·00 |
| Average - - - - - | 70·47 | 29·53 | 100·00 |

E. FRANKLAND.

App. A.J.

# APPENDIX A.J.

## Extracts from Documents in the possession of the Erith Local Board.

*Erith Drainage.*

3, Whitehall Place,
London, S.W.,
17th September 1877.

Gentlemen,

In accordance with your clerk's letter of the 23d August, requesting me to report upon the present state of the drainage in the parish of Erith, I have had the whole of the district carefully surveyed, and have annexed to this Report a schedule of details obtained from the most reliable information I could get, which will show you how the various streets and houses are at present drained. Underlined in red are those which appear to be in the worst condition.

Accompanying this Report is a plan showing how I have subdivided the four districts as requested by you, and on this the blue lines show the existing sewers in Erith, and the red spots indicate the places underlined in the accompanying schedule.

From these details you will perceive that at present out of the whole of your district the sewage is only carried through a system of sewers in Erith proper, and these discharge into the river. In the other districts, cesspools of various depths have been universally used, and in some cottages which have recently been supplied by the Kent Waterworks Company, the old wells down to the chalk have been covered over and converted into cesspools. I need scarcely say, that this state of things requires immediate attention, and I feel confident that nothing but a general system of sewage for the whole district will meet the requirements of the Local Government Board.

A comprehensive plan should be at once prepared, and the necessary steps taken to obtain the sanction of the central authority to its being carried out.

I am, &c.
(Signed) Edward Easton.

To the Erith
Local Board of Health,
Erith, Kent.

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*State of Sewers in Erith.*

Through Wheatley Terrace there is a large brick drain. This discharges into the river opposite the gardens through an iron pipe having a flap valve on the river bank. This drain is said to be between 3′ 6″ and 4′ 6″ high and 2′ 4″ wide.

This is joined in Appold Street by a brick sewer commencing on the Wheatley Terrace side of the tramway. This drain said to be 2′ 4″. A few houses are drained above the railway branch through a six-inch pipe drain which is carried under the line.

The brick sewer is carried up from Wheatley Terrace the same size to crossing of High Street and Pier Road, and then continued up to opposite "Prince of Wales" public-house in Avenue Road. A pipe goes up High Street from the Pier Road to opposite Messrs. Catchpole's Brewery. The large sewer is reported to be in good condition. Opposite the "Prince of Wales" it receives a drain from the Avenue Road, and another from the backs of Crayford Road. Another branch is also taken up Queen Street and is carried up Queen's Road, and joins the sewer from Bexley Road in Pier Road, and another branch in Queen's Road is taken the other way to Avenue Road, Albert Villas, in the Queen's Road are drained at the back into Avenue Road, and then into brick sewer.

In Pier Road an iron pipe is taken up over the railway bridge, and continued by an earthenware pipe to the top of the villas.

This joins the large sewer at the corner of Pier Road and High Street.

Another branch joins the sewer opposite Mr. Stones, in Pier Road, coming from Custom House Cottages and the back of Collrook Street.

In Pier Road and High Street several of the houses are drained through the front, and have, as a rule, separate drains. This is only exceeded in case of three and four houses belonging to one owner. The only ventilation to large sewer is near the public hall. It used to be ventilated, but these have been stopped up some time since.

*Outfall by Flour Mill.*

This is said to be a private drain, draining on its way down several cottages, and is reported to have been well put in.

This sewer goes through Mr. Steers' stables up at the back (right hand) of Crown Street, 9-inch pipes are laid all the way; it is trapped by a syphon where it turns off the road. There are five houses in High Street drained into this at the bottom.

At the bottom of Crown Street a pipe joins this sewer, draining all the houses on the left hand, going up to No. 18. A small drain is then carried above this to drain the "Rose and Crown." This sewer goes up the back, and comes through the opening by R. Austin's shop.

*Outfall from Bexley Road.*

This sewer is laid from the police station in Bexley Road through High Street, and discharges into the river opposite the Causeway through a brick sewer. At the bottom of the Bexley Road it receives two drains, one from the back of the houses on the left going up, and another from a small yard on the right. From the information obtained, it appears these two branches are too small to properly carry off the drainage. At the upper end a small line of pipes is laid across the road to drain the "King's Arms" public house.

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To the Erith Urban Sanitary Authority.

Pier Road, Erith,
16th January 1878.

Gentlemen,

In presenting my first annual Report to you, it is with a feeling of great joy that I congratulate you upon the fact of there not having been a single death from any infectious disease during the last six months, and further, that during the year there has been a complete absence of any epidemic.

It is true there were a few isolated cases of small-pox imported into the district at the commencement of the year, but prompt action was taken, and the disease did not spread.

The cases of typhoid fever that occurred in Crown Street and Back Lane at the spring were examined into, and the wells either cleared out or closed, and since then there have been only a few cases reported to me, and these of a mild character.

I would here suggest the advisability of having all wells closed, and enforcing the company to lay on a constant supply of water to every house, as nearly all the wells in the village are influenced by the tide of the river, and many must be more or less affected by the river water, which, as you know, is greatly impregnated with sewage.

As I know you have given instructions for a complete system of drainage to be planned for the district, it is not worth while to trouble you with many details with which you are already acquainted; but I would, however, have you bear in mind that it would be as well if you could at the same time bring into your system the whole of the North End in the parish of Crayford, and I think the Local Government Board would, if you asked them, give you power to extend your boundary as to take in that portion of Crayford parish which really forms a part of Erith town.

The cases of small-pox above alluded to were imported into the parish from Crayford or London in the first place.

I have from time to time reported to you upon different portions of the parish which in every case has received prompt attention.

The well behind the "Standard" public house, which is situated far too near the cesspool and urinal, and which I reported to you a short time since, your inspector tells me the landlord declines to close without the water is analysed, I directed the surveyor to ask you to have this done.

The drainage down Manor Road, to which attention has constantly been drawn, you have informed me is postponed awaiting the report upon the general scheme of drainage.

You will remember in the Summer some of your board attended at Dartford to consult with the guardians

respecting the advisability of erecting a joint hospital for infectious fevers, &c., but nothing came of it. I would strongly urge you, however, to erect one for yourselves, or get Crayford and Bexley to join you. This is more forcibly impressed upon me as there is a case of small-pox at present in the village which I have no power to enforce to go into the Union Infirmary, and who, therefore, is now being treated at her own home.

A special report upon this case will be before you.

The death rate for the year has been remarkably low, as you will see by perusing the accompanying table, only averaging 13·1 per 1,000, calculating for increase of population.

Believe me, &c.

(Signed) Fredk. B. Jessett, F.R.C.S.E.,
Medical Officer of Health.

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*Annual Report for the Year ending 31st December 1878.*

To the Urban Sanitary Authority, Erith.

Pier Road, Erith,
29th January 1879.

Gentlemen,

The health of the parish has been even better this year than it was last, as you will see by perusing the subjoined tabular reports.

With regard to the influence affecting or threatening to affect injuriously the health of the parish, I would in the first place point out those that actually do affect the public health injuriously, and then allude to those influences which threaten to affect it.

Firstly, then, a great part of the parish is either very imperfectly drained, or has no drainage at all, I allude in the first place to that property that is drained into the general sewer and has no ventilating shafts, and the closets and sinks of which are very indifferently trapped. Among this property may be classed a great part of Queen's Road, Crayford Road, and the High Street; that part of Queen's Road known as Stonleigh Villas, as my report on that property showed was in a most fearful condition, the drain in many instances actually being ventilated by means of a waste water pipe directly into the houses, the result being a fatal case of typhoid fever. This state of things is, however, remedied, or in course of being so.

In Crayford Road the drainage, although going into the main sewer, is very imperfect, and there is a complete absence of ventilation, however, none of the closets being furnished with cisterns, there is no water to flush the drains, excepting what the people throw down, the consequence being that often the drain gets clogged.

The sinks in nearly all this property are very bad, being furnished merely with bell-traps, which in many instances are either broken or otherwise out of order.

Next with regard to that property that is not drained at all or are merely drained into very indifferent cesspits.

This represents a very large portion of the property, viz.: Belvedere Abbey Wood, Northumberland Heath, Manor Road, Erith, Lesney Park, West Street, and South Street, Erith.

In Belvedere the drainage is very bad. Many of the gardens at the rear of the houses having several cesspits in them, so much so, that in some of the best shop property, I am told, it is difficult to sink any more.

This is a state of things that must be remedied.

Abbey Wood in cases is nearly as bad, but not being so densely populated, the same ill effect is not so likely to result.

Northumberland Heath is rearly worse than either, as the population here is very poor and densely populated. The different districts named in Erith are all, with few exception, equally bad.

The only remedy for these evils is a thorough and complete system of drainage. This, I am glad to find you studying; the plans for draining the parish prepared for you by Mr. Easton is likely shortly to be very effectually carried out.

So much for the drainage; now for the water supply. This is most important, more especially as I have shown so much property is only drained into cesspits. There are still a great number of houses and cottages not supplied with water from the company, the occupants having to get the water for drinking and other purposes from wells in many cases in close contiguity with some cesspit or with some pit which has been closed. This is the case in the Pier Road (Francis Cottages), Park Spring Place, High Street, some parts of Bexley Road, formerly known as Back Lane, Northumberland Heath, and Abbey Wood.

Belvedere is, I think, nearly all supplied with the company's water.

Now, of course, water supply from the main is very likely to, and in point of fact does, very quickly fill up cesspits, and they have therefore to be constantly emptied.

But on the other hand, if wells are in close vicinity to cesspits, they run the great risk of becoming polluted with sewage. It therefore becomes a choice of evils of which it is your duty to choose the least, which is, of course, that which runs the least risk of affecting injuriously the health of the occupier, viz., a good supply of water from the main.

Having alluded somewhat fully to this part, let me briefly notice that which threatened to prove injurious to the public health.

I think nobody who has noticed the large quantity of ice washed into the shore in Erith Reach about Church Hole, the ballast wharves, the crown quay, and the pier, cannot but be struck with the very strong set of tide running down from London into Erith, the result of which must be, I think, to wash a large quantity of the sewage sent out at Barking and Crossness outfalls into Erith, and depositing it upon our banks.

The parish has been peculiarly free from all epidemic of infectious disease, as although there have been some cases of scarlet fever, the disease has not spread at all, in fact, as will be seen by the tabular report, there have been only eight deaths during the whole year. One family in which two deaths occurred undoubtedly contracted the disease in London. In every case prompt measures have been adopted, and to this I attribute the limited number of cases.

*Offensive Trades.*

There are still some offensive processes of trade going on in Erith marshes, at the artificial manure works, and glue works, the owners of which do not take proper precautions to consume the smells emitted in the manufacture of their articles. This, in the coming Session of Parliament, will be dealt with, and a Bill introduced which, if passed, will enable you to deal with these nuisances.

*Sanitary Improvements.*

During the year at my suggestion a number of wells have been closed which were found polluted with sewerage, and I hope in the course of time to get rid of all the wells situated in the town.

Picardy Street has been much improved in every way, the drainage however, like the rest of Belvedere, cannot be properly undertaken until the whole parish is thoroughly drained.

Stoneleigh Villas have been thoroughly inspected, and the drainage is being now put into a proper condition. When completed I shall make another survey of this property and report thereon.

During the year I have visited, with many members of your Board, the Hertford Sewage Works, with the view of reporting thereon as to the advisability of our adopting the same system as is carried out at Hertford. I sent in a full report of this to your board.

Subsequently I visited Aylesbury and inspected the "A.B.C." system with the same object.

A great part of the drainage that I recommended you to do, and which you investigated, have been postponed, awaiting the decision as to the best mode of draining the whole parish.

I think the board may congratulate themselves on the excessively low death rate of the parish which would compare most favourably with any other town in England, and as this is the case now when we are bound to admit our drainage, &c. is far from perfect, may we not fairly hope to attain to a still higher degree of perfection when the admirable drainage scheme sketched out by Mr. Easton is carried out.

There have been 142 deaths in the parish during the year; of these nearly half have been either over 60 years of age or under 1.

This gives, allowing for increase of population, the extraordinary low death rate of 11·83 per 1,000.

Now it will be no doubt intering to you to know approximately the death of the different districts, viz., Erith proper, Belvedere, and Northumberland Heath.

At the last census, at Belvedere and Abbey Wood, there were 623 houses, with a population of 3,004 people. Northumberland Heath 153 houses, with population of

App. A.J.

675, and Erith proper 911 houses, with a population of 4,294 inhabitants. The marshes and Crossness having 56 houses and 316 population.

This is an abstract of the census of 1871. Let us see then how the number of deaths stand in relation to the population of each district, we shall find it thus:

| | Population in 1871. | Deaths. | Death rate. |
|---|---|---|---|
| Erith - - - - | 4,294 | 68 | 16·07 |
| Belvedere - - - - | 3,004 | 52 | 17·3 |
| Northumberland Heath - - | 675 | 12 | 17·7 |
| Marshes - - - - | 316 | 3 | — |
| Violence - - - - | — | 7 | — |

This being the population at the last census, and as Erith proper has increased considerably more since then than either Belvedere or Northumberland Heath it follows if one could get at the exact population now that the death rate of Erith has been considerably lower than either of the other districts, but even taking the rate at the last known population it is still remarkably low.

Believe me, &c.,

T. Parish, Esq., Clerk to the Board. F. B. Jessett.

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To the Erith Sanitary Authority.

Pier Road, Erith, Kent,

Gentlemen, October 27th, 1879.

I visited with your Inspector of Nuisances the different manufactories on the river bank situated in your parish.

The building furthest from Erith was empty but had been used recently for experiments.

Next to this are Bevington's Artifical Manure Works, the manure being the product of boiling scutch by steam at a high pressure with sulphuric acid this afterwards being run into open vats, and when sufficiently dry being thoroughly dried over long brick kilns.

Precautions appear to be taken here for the prevention of escape of the vapour while the scutch is being boiled, but the smell from the evaporation when run into the vats is very offensive, as also is the smell while the product is being dried over the kilns.

More care should be taken here, in the first place the boiled liquid should not be allowed to run out of the boilers until quite cold, and then when run into the vats I think there should be good covering of lime thrown over the whole.

The drying over the kilns should be avoided as much as possible and certainly not used until the product is very much drier than is the case at these works, I believe this drying is detrimental to the commercial value of the manure as large quantities of ammonia are driven off by the heat.

Collins, late Brown, Manure and Glue Works are contiguous to the last named factory being separated by a wide and very offensive ditch filled with filth, and the drainage from certain cottages a short distance off. This ditch should be filled in and some large glazed earthenware pipes placed there to carry off the drainage.

Collin's works were not working at our visit, the boiler being out of order, but the whole building was very dirty. Their business appears to be to extract glue from old horses hoofs, hide, shedding, &c. and then from the scutch to treat it with oil of vitrol, and boil by steam in closed boilers, then to run the product under cover to dry. They do not use any kilns, and the manager informed me that they treat the boiled scutch after skimming off the fat with saltpetre and sugar scum to prevent the smell.

It did not seem to have the desired effect, however, as the smell was very bad.

Here there were flues connected with the boilers and run into the main shaft. This appeared to be very bad as the steam, of necessity, was carried from the boiling scutch up the flues to the shaft and then wafted whither the wind took it. These flues should be done away with and the scutch boiled under high pressure as at Bevington's.

More cleanness should be observed at this factory.

The building has been erected some three years.

Next to Collin's are two very large factories in course of erection, the first called the French Alum Company and the next the Metal and Chemical Company for making paint.

The alum in the first washing extracted from alumite imported from Rome; the ore is ground into powder and then treated with sulphuric acid which thins down the alum.

The paint is made from an ore imported from Ireland containing 24 per cent. each of tin and lead, this is simply ground into a very fine powder and mixed for paint.

The paraffin works were then visited but there was nothing to complain of there.

There are number of works situated on the other side of the river that were said to be very offensive.

1st. On the east side of Rainham creek there are three manufactories of artificial manures. One where bad fish are treated and fat boiled, reported as being very bad, then comes George Wilson, and Miller and Johnson's Artificial Manure Works.

To the west of Rainham Creek are some Bi-carbon works and others.

Doubtless we are affected at Erith by these works, and it would be well if some steps were taken to enforce them to take every available measure to consume the noxious odours arising from their trades.

Believe me, &c.

F. Parish, Esq. F. B. Jessett, F.R.C.S.E., Medical Officer, Health.

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To the Erith Local Board,

Pier Road, Erith, Kent,

Gentlemen, 24th November 1879.

The nuisance arising from the Artificial Manure Works since my last report has been, if possible, worse than ever, and I think the time has arrived when you should exert your power to abate this nuisance.

Mr. Collin's works have not been at work lately, as the boiler is out of order, so that the smell must be produced by Messrs. Bevington's on this side of the river.

Clause 114, Public Health Act deals very clearly with the question relating to offensive trades in any urban district, and the preceding clause enables urban sanitary authorities to make byelaws regulating the action of offensive trades.

Clause 91 defines a nuisance in subsection 6 relating to factories, workshops, &c. as being a nuisance or injurious to health, and the following section treats with the method of abating such nuisance.

Clause 115 gives power to urban authorities to deal with any manufactory certified to be a nuisance or injurious to the health of any of the inhabitants of the district of an urban authority when situated without the district.

I trust that the board will take very decided steps to abate this nuisance, as it is undoubtedly a nuisance within the meaning of the Act, and considerably deteriorates from the value of property.

If there is any doubt as to the interpretation of the section above alluded to, would it not be better for the board to instruct your clerk to state the case, and obtain counsel's opinion as to the best course to pursue.

Yours, &c.

F. Parish, Esq. Fredk. B. Jessett, F.R.C.S.E., Medical Officer, Health.

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To the Urban Sanitary Authority, Erith.

*Annual Report for the year ending December 31st*, 1879.

Pier Road, Erith, Kent,

Gentlemen, 22nd January 1880.

There has been no material change in the general condition of this parish since my last annual report.

The influences threatening to affect the public health injuriously have been in many cases removed, I refer especially to the closing of a number of wells, the water from which has been analysed and found unfit for domestic use. These wells are chiefly situated in the lower part of Erith, and one or two in Northumberland Heath. In every case an order has been issued for the owners to close these wells and supply water from the West Kent Waterworks Company . . . .

I may here mention as threatening to affect injuriously the public health the horrible smells arising from the manufactories on the river. These I shall show later in my report the board are using their best endeavours to put a stop to . . . . .

There have been during the whole year a few cases of scarlet fever throughout the district, but of a very mild character.

There have been 11 deaths, however, caused by it, but in the majority of cases they have been caused by secondary disease brought on from insufficient care during convalescence from the fever.

Five deaths have occurred in Erith, four in Belvedere, and two at Northumberland Heath. It was difficult to ascertain the origin of the fever. In every case, however, strong sanitary measures were taken to prevent the spread of the disease, and this proved very effectual, for at present there is not to my knowledge any fever in the parish . . . . .

I would again draw attention to the fact that undoubtedly a large quantity of sewage sent out from Crossness and Barking is carried by the current on the river on to our shores.

Strenuous efforts should be made to prevent this, but at present the outfalls are protected by the Public Health Act.

*Offensive Trades.*

This is a subject which has occupied the attention of your board for some time, and it is with very great satisfaction that I have found you are determined to use your utmost endeavours to enforce the owners of the different glue manufactories, and other offensive trade's works to abate the nuisance arising from their manufactories.

I have visited, with your inspector, all the works on this side of the river, and sent my report in to you.

I am certain, if the different owners used the very best known measure to abate the nuisance arising from their works, that the smells complained of would be done away with, or at any rate reduced to so small proportion that they would cease to be perceptible at such a distance as Erith and Belvedere.

I would, however, suggest to the board that a petition should be sent to the Home Secretary urging him to introduce his Noxious Vapours Bill Act in Parliament during the coming session, and I think with the coming election in view the members of the county might be written to with a view of their bringing the subject prominently before the Home Secretary.

The mortality of the district, although higher than last year, still keeps very low.

There have been 165 deaths this year as against 142 in 1878, 50 of the 165 deaths were above 60 years of age and 38 under 1 year, being more than half of the whole mortality, of the 50 deaths over 60 no less than 16 occurred at the Royal Alfred Institute, of the 50 deaths above 60 no less than 32 were over 70 years of age, and the total age of the whole 50 amounted to 3,704 years, or an average age of 74 years.

Dividing the deaths among the several districts, viz. (1) Belvedere, including Abbey Wood and the Marshes, (2) Erith, and (3) Northumberland Heath, we shall find the following result, taking the population of each district at the number of population at the last Census, 1871, viz.:

| | Population, 1871. | Deaths. | Death Rate. |
|---|---|---|---|
| Erith - - - - | 4,300 | 73 | 17·6 |
| Belvedere - - - - | 3,320 | 49 | 14·8 |
| Northumberland Heath - - | 675 | 15 | 22·2 |
| Royal Alfred Institute - - | — | 16 | — |
| Cottage Hospital - - - | — | 6 | — |
| Violence - - - - | — | 6 | — |

I have, in the above table, put the whole of the Marshes, Abbey Wood, and the outfall into Belvedere District, and taken out all the deaths occurring at the Royal Alfred Institute which reduces the death rate to a minimum.

The population of that district has not, I think, materially increased since the last Census, whereas Erith population has considerably increased, as also has the Northumberland Heath District.

The death rate for the year, allowing for increase of population, and excluding the deaths occurring at the Royal Alfred Institute is at the rate of 12·5 per 1,000, this is slightly higher than last year, and may be accounted for by the excessively wet cold weather, which has carried off a very large number of old people and children.

Deaths from disease of the respiratory organs, included in Table 29 and 30 of the Tabulated Report, having been unusually high.

Included in this number also are six deaths from accident, four of which were bodies washed up from the river, having been discovered, and, therefore, really not part of the deaths occurring in the district from disease . . . .

In reference to my remarks on the extension of fever, I intended to draw attention to the desirability of the board having a hot room where clothes, bedding, &c. might be brought and thoroughly fumigated and disinfected. By this means, I think, an epidemic, should it arise, might be much more speedily cut short, and the risk of an epidemic occuring, much reduced by early and proper disinfection of the clothes, &c. of those who have fever lightly.

I append the printed forms by which you will see the number of deaths at each age, and the disease of which they died.

I am, &c.

FREDK. B. JESSETT, F.R.C.S.E.,
Medical Officer of Health.

F. Parish, Esq.

*Here follows the tabular statement.*

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COPY MEMORIAL, signed by 69 RATEPAYERS of BELVEDERE, presented to ERITH LOCAL BOARD on 14th September 1880.

To the Local Board of Health of Erith.

GENTLEMEN,

WE, the undersigned inhabitants and ratepayers of Belvedere, beg to call your attention to the continuous and unabated nuisance arising from the factories on the river banks, the fumes and vapours are having a serious effect upon the health of our families, and we must ask you to put in force any powers you may have to remedy the evil with as little delay as possible.

We are, &c.

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To the Erith Local Board.

Offices, High Street, Erith,
14th December 1880.

GENTLEMEN,

I HAVE visited the manure and other works on this side of the Thames, according to the instructions I have received.

On Saturday, 4th December, at 8·45 a.m. wind west, Bevington and Co. were boiling, and had been doing so the preceding day, Friday, with the usual smell arising, the concentrator provided to assist in the prevention of smells, had been placed in position and fixed, a concrete foundation for tank for condenser had been put down on cross planks about four inches apart. I found in enlarging foundation side of concentrator the smell from removal of earth was more obnoxious from that of boiling.

Messrs. Callender and Sons had been at work the first five days of the week, and were cleaning and chipping on this day, Saturday, which is their accustomed way of conducting their business.

Monday the 6th instant, at same time, with wind in same direction, I visited Messrs. Bevington & Co.'s works. They were boiling scutch, and intended doing so for the two next consecutive days, which was done, the engineers were still fitting up the concentrator.

At the same date, and near the same time, Messrs. Callender and Sons were at work with the two outside boilers, and shed, where damp coarse sheeting was prepared; the three boilers in shed in centre of premises were having the flues altered, and agitators put into the boilers worked by steam, that they might be covered in, to prevent the escape of gas, to which they were liable when worked by hand, the foreman stated the two outside boilers now at work, would be placed alongside those now being altered, as soon as they were completed, that they might be all under one roof, and worked with same engine.

I have seen an open ditch taking refuse from Messrs. Price and Co.'s works which is offensive, and com-

App. A.J.

plained of by Messrs. Callender and Son's foreman. This I think should be attended to by the Thames Conservancy as it flows into the river.

Friday, December 10th, I found a very bad smell when leaving the office 5.15 p.m., which I should think caused by the boiling of scutch, which must have arisen from works on the Essex side, the wind being about north.

10.30 a.m., December 13th, 1880, Monday, wind west, Messrs. Bevington and Co. boiling, will continue doing so for two more days, and then not again until the alteration of the works are completed; the tank for consider 24′ 0″ × 10′ 0″ × 2′ 6″ is built, and the inner side cemented. The excavation is proceeding for putting down pipes which have not at present arrived.

Messrs. Callender and Sons are continuing their alterations which will take some time before they are completed.

On Friday, December 10th, on passing I found a very obnoxious and offensive smell arising from Messrs. Collins' Work either from the turning of hide chippings or from being placed in solution in vats alongside the river wall.

The drawings left for approval at last board meeting by Mr. Bleeze for house to be built I believe in Brook Street are very vague, and no specification being sent therewith, I would suggest they be amended.

I have also received drawings and specifications for building stables for S. S. Baiss, Esq., Belvedere, which I believe are in accordance with the bye-laws.

The house of Northumberland Heath where typhoid fever occurred has been fumigated with "bi-sulphide of "carbon" in every room.

The dangerous earth on Knee Hill, Abbey Wood, has been removed.

Application has been made and forms filled in for slaughter house licenses for Messrs. C. Weller, J. Hind, W. Smith, G. Alcey, and Mrs. S. Robertson.

Mr. T. C. Hayward, Surveyor of Eltham, would be pleased to know the terms the board would let the steam roller upon and if an arrangement could be made for use of same.

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*Annual Medical Report for the Year* 1880.

To the Erith Local Board.

Pier Road, Erith, Kent.

GENTLEMEN, January 28th, 1881.

VERY little change has taken place in the general condition of the parish.

Influences threatening to injuriously affect the health of the neighbourhood have been removed as far as possible. A number of wells have been closed especially in the town itself and the company's water laid on.

Other wells are under inspection * * *

There has been very little building in the parish this year. The cottages that have been built are, however, of a very superior character to those built some few years since, especially in a sanitary point of view.

The very elaborate and thoroughly exhaustive plans for draining the whole parish as prepared by Mr. Easton last year are still in your offices but the time has not at present arrived apparently when they are likely to be carried out. In the meantime the whole of the Belvedere, Abbey Wood, and Northumberland Heath District are drained into cesspools.

This is much to be regretted, but doubtless the time is at hand when you will see the necessity of carrying out the very complete system of drainage above referred to.

Your board has during the year taken very active measures to abate the nuisance arising from the different factories along the river. I have inspected and sent in two or three reports upon the condition of those factories situated on this side of the river, and further you have appointed Mr. Ogston (analytical chemist of London) and he has visited not only those factories in your own parish but also those on the other side of the river which threaten to affect injuriously the health of the inhabitants of your district.

The result of your labours has been to enforce Messrs Bevington and Messrs. Callendar to stop their works until such time as they have erected suitable machinery to abate the nuisances complained of. Messrs. Price and Co. are now being attacked and doubtless you will be entitled to enforce them also to erect suitable machinery for the same object.

Having satisfactorily arranged for mitigating the nuisances arising from the factories in this parish you will doubtless during the coming year give your attention to those factories on the other side of the river.

I have visited again the Picardy St. property and find it greatly improved, but the open ditch or, I may say, open cesspool at the end of the street still exists and should be done away with as it must undoubtedly affect the health of the inhabitants in its immediate neighbourhood injuriously.

The privies too are still as bad as ever, and the only means of improving them is to have a thorough system of earth closets superintended by your own Inspector of Nuisances.

There was a very sharp and extensive epidemic of measles at the commencement of the year.

It commenced at Northumberland Heath and here your board ordered the National and Sunday schools to be closed for one month.

The epidemic, however, extended to Lessness Heath and Erith and as the disease was of a very mild type and from experience of closing the schools at Northumberland Heath you found did not stop the tide of the epidemic it was not necessary to close the larger schools at Erith or Belvedere.

Out of the whole number affected only seven died and these mostly from secondary affections such as bronchitis.

There have been a few isolated cases of scarlet fever in the parish. At Northumberland Heath there were a few cases of typhoid fever, one of which terminated fatally. Diarrhœa was prevalent during the summer among infants, but there were only nine deaths.

A few isolated cases of chicken pox have also occurred. The general health of the parish has been very good during the year, the mortality being slightly less than last year, viz. 161 as against 165 in 1879. The death rate of the parish during the year, allowing for increase of population, is 1,464 per 1,000.

Thirty-nine of these deaths were over 60 years of age and 44 under one year.

Twelve deaths occurred at the Royal Alfred Institute and four in the Cottage Hospital.

Dividing the deaths between the several districts, viz. (1) Belvedere including Abbey Wood and the other marshes; (2) Erith; and (3) Northumberland Heath, you will notice the following death rate taking the population of each district at the number of population of each district at the number of population returned at the last census.

| — | Population, 1871. | Deaths. | Death-rate. | Measles. |
|---|---|---|---|---|
| Belvedere - - - | 3,320 | 61 | 18·4 | 2 |
| Erith - - - - | 4,300 | 60 | 13·95 | 5 |
| Northumberland Heath - | 675 | 12 | 17·6 | 2 |
| Royal Alfred Institute - | 675 | 12 | — | — |
| Cottage Hospital - - | 675 | 4 | — | — |
| Violence - - - - | 675 | 12 | — | — |

Comparing this table with last year you will notice that Belvedere heads the poll considerably, having jumped from 14·8 per thousand in 1879 to 18·4 in 1880, both undoubtedly very low death rates. Erith, on the contrary has dropped from 17·6 per thousand in 1879 to 13·95 in 1880 while Northumberland Heath remains about the same.

The number of deaths in Erith for were 1879 76, as against 60 for 1880, while Belvedere showed 49 in 1879 and 61 in 1880.

The number of births in the whole district was 336 or rather more than two to every death registered. I append hereto the usual tabulated forms as furnished by the Local Government Board, which will show you at a glance the ages and diseases from which the majority of the deaths occurred. A table of new cases of sickness has been added, and through the dispensary books I have been enabled to tabulate a large number of diseases that otherwise it would be impossible to collect particulars of.

Believe me, &c.

F. Parish, Esq. FREDK. B. JESSETT.
Clerk to the Board.

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To the Erith Local Board,

Pier Road, Erith, Kent,

GENTLEMEN, February 27th, 1882.

I HAVE to report a death from typhoid fever occurring in Queen's Road, Erith.

The sinks in the cottages in this street run direct into the drainage and the small bell trap, which affords the

only protection to sewer gas coming into the houses, are in many cases out of repair. This should be altered and the pipe from the sink be disconnected from the drain leading into the sewer.

The Company's water is laid on here, stand pipes being provided to each cottage over the sinks, the occupiers catching what water they require during the short time the water is turned on. I think it would be better if proper cisterns were provided for these cottages. * * * * * *

*Noxious Vapours.*

The smells from Messrs. Proctor and Bevington on Tuesday, February 21st and Thursday 23rd, were worse than I ever smelt them. On Tuesday the wind was N,N.E., and on Bostol Hill the smell was such as to cause patients of mine to close their windows although it was highly essential for them to be open.

On Wednesday a most sickening smell pervaded the neighbourhood. I believe from the state of the tide it must have been sewage. The wind was N. and the smell worst at Beadle's Wharf.

I have to draw your attention to a low wall which exists behind Mr. Stone's yacht building yard. Here a man fell over and was killed.

In this same yard the privy accommodation is very bad.

Yours, &c.
(Signed) Fredk. B. Jessett,
F. Parish, Esq. Medical Officer of Health.

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Pier Road, Erith, Kent,
February 28th, 1881.

To the Erith Local Board.

*Noxious Vapours.*

Gentlemen,

The effluvia from the glueworks was very bad indeed on Wednesday, February 16th.

I don't know whether it came from Messrs. Bevington or Collins, but it was reported to me by many inhabitants as being as bad if not worse than ever. It would be as well, I think, if your inspector made inquiries as to who was working on the day mentioned.

*Small-pox.*

A case of small-pox has been reported to me at Mr. Barnes, grocers, North End. I have given instructions to have the shop closed, and have written to the inspector of Crayford parish, to issue notices to the owner of the shop; also to supply the necessary disinfectants.

Believe me,
Yours, &c.
Fredk. B. Jessett, F.R.C.S.,
F. Parish, Esq., Clerk. Med. Off. Health.

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22, Mincing Lane, E.C.,
15th March 1881.

To the Erith Local Board,

Gentlemen,

In accordance with your wishes conveyed to me in a letter from Mr. Parish on the 4th instant, I have made another visit to the factories on the south side of the river, and have to report to you the condition in which I found them.

Messrs. Callendars were not at work on the day of my inspection, but I find they have attached to one of their boiling pans an apparatus which they believe will prevent the escape of oily vapours into the air. This consists of a corrugated iron fitting fairly closely over the pan or boiler from which, at one end a pipe enters, connected with the furnace above the fire bars. The anticipation is that the vapours which have been proved to be so offensive, will in passing over the fuel, in contact with the hot flue, be burnt up to become innocuous. My impression is that this plan will not be effective because the considerable amount of watery vapours which as well as the oil is discharged during the boiling will keep down the temperature of the whole, below the point at which combustion would take place. There would have been a better chance of success in my opinion if the pipe leading from the pan had been taken below the furnace instead of above it. Mr. Callendar told me they were to commence working on the 14th March (yesterday) so that with a favouring wind the result will soon be known in the neighbourhood. It will be remembered that in one of my reports to you, I expressed the opinion that some arrangement by which the shale oil vapours should be condensed would give the greatest security against annoyance, and I fear that with a varying intensity of fire under the boilers the plan now being tried can scarcely be expected to give uniform results, if indeed it provides any serious remedy.

Messrs. Price's works were visited, but I was not fortunate enough this time to meet Mr. Harvey. With regard to the particular process of which I have more than once spoken, viz., the refining of oil by means of sulphuric acid, and about which complaints were more than justified, Mr. Harvey told me that an alteration was to be made in the situation of the building in which the process was carried on, and that some alterations in the process itself was to be made, but Mr. Harvey did not say that the steam conveying acid vapours from the refining cisterns into the air was to be condensed and so got rid of, so far as Erith is concerned. This, as I have more than once explained, will be found to be necessary, and as it can be done with very little cost without interfering with the course of the business, I think it ought to be provided for at once. The treatment of the oil occupies, I believe, two hours every day, but it was not going on whilst I was present. One other disagreeable vapour, which has up to quite lately been allowed to escape into the air, is now conducted by a pipe into the furnace below the boiler in which it is produced, here it is said to be destroyed; the resulting gases passing into the chimney, and so, of course, out of the range of observation whilst I was on the premises. It was smelling very much whilst I was there, but the manager explained that this was due to a defective pipe through which the vapours were leaking, and that this fault was to be immediately remedied. Many of Messrs. Price's processes are evidently intermittent; it is impossible, therefore, for me to say if there are more than those I have mentioned to which their attention should be drawn, and it can only be after putting an end to the offensiveness of those that are known to be objectionable, one by one, that certainly on this point can be arrived at.

Mr. Collins' factory was not open to me, and I am, therefore, unable to inform you of its internal condition. There is great prepartion for work on a considerable scale, both for glue making and scutch boiling, as evidenced by the collection of large quantities of material on the wharf, and it is certain that unless great improvement in the boilers and machinery, I saw at my last visit is made, before they commence to work very great annoyance will be created in the neighbourhood.

Messrs. Proctor and Bevington. This firm have put up some extensive machinery with the view of condensing their acid vapours and dying their manure completely in mixers before it is exposed to the air. If the apparatus is as successful with their compound as it has shown itself to be in other cases, the result should be satisfactory since nothing is allowed to escape. On the occasion of my visit on the 8th, however, some difficulty was experienced in the working of the machine almost for the first time, and a good deal of vapour was escaping from the boiling pans, Mr. Bevington told me they had spent 700*l.* upon the machine, and some faults having shown themselves in it they were about to make alterations and hoped to get good results.

Messrs. Bevington have always seemed to me to be seriously endeavouring to do the best they can, but I must say there was a good deal of smell on Tuesday last, owing I could see, in a great measure to the want of experience of the new machines on the part of those in charge.

Inasmuch as in only one instance is there any admission on the part of owners of factories that the slightest annoyance is occasioned to the neighbourhood by anything proceeding from their respective works, opinion on this point can only be formed from the outside, and as I have no doubt they honestly believe what they say, it will still be necessary to draw their attention after careful observations to the odours which can be distinctly traced to them individually.

It is scarely necessary to draw your attention again to the works upon the north side of the river. Messrs. Crossfield, Messrs. Miller and Johnson, and Messrs. Wilson, the former more especially are with fair winds sending "noxious vapours" to Erith and Belvedere,

App. A.J.

and undoubtedly they ought if possible to be prevented from doing so.

I am, &c.
(Signed) G. H. Ogston.

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Mincing Lane, London, E.C.,
30th August 1881.

To the Chairman of the Erith Local Board,

Dear Sir,

In consequence of a letter from Mr. Parish, intimating your wish that I should again visit the factories on the south bank of your river on the 16th of this month, accompanied by your surveyor, I inspected all those that are mentioned in my former reports ascertaining what changes had been made in them, and what was proposed to be done.

Proctor and Bevington have completed the erection, and have worked the apparatus to dry their manure, and at the same time to condense the vapours arising from it. A considerable sum of money, 700*l.*, I believe, has been spent upon it, but I understand the machine is not yet a complete success. How far it falls short of this I cannot say, as on the 16th it was not at work, and additions are still being made to the apparatus. The character of the material with which Messrs. Proctor and Bevington have to deal differs considerably from the simple refuse fish that those gentlemen saw so completely dried when they made the purchase of the machine, and I regret they did not adopt my advice to experiment with their own stuff before adopting the plan. I did not see either of the partners, but pointed out to their manager a mode of working by allowing the mixture to cool to a certain point in the cylinder before discharging into the pits, which will mitigate the nuisance, until the additions are completed, and which it was promised should be adopted.

Messrs. Collins have not been boiling "shutch" since my last visit, and have made no alterations whatever in plant provided for the purpose. They are intermittently engaged in making glue, and have a large quantity of the material from which it is produced on the premises. There was, however, nothing to complain of, and, indeed, glue making if properly carried on need create no nuisance.

A fish-drying work, immediately adjoining Messrs. Proctors' on the upper side which have been working for some time past, are being put into repair, but I could not learn from the men engaged on the engines who were the proprietors, or what class of business it was proposed to carry on there. If fish-drying is to be re-established, attention should be directed to the place.

Sir Chas. Price and Co. have made some alterations in their works that will diminish the quantity of noxious vapours and some smells that were noticeable at my last visit to their works. Notably they have fixed a powerful, and I should think an effective condenser, to intercept the volatile acrolive resulting from the distillation of glycerine. Some months ago much of this escaped into the air, partly from a pipe which was leaking, but care seems to have been taken to put an end to this source of complaint. They have also erected air-tight cyclinders for the reception of offensive "cotton "oil foots" which comes alongside their wharf in "barges, and is drawn directly into these receptacles by exhausting them of air so that no exposure of the foots is allowed. This, no doubt, will be a great improvement.

With regard to a complaint I made to Mr. Harvey, that in refining some of their oil by steam and sulphuric acid and all the sulphurous vapours were allowed to pass into the air and suggesting that means ought to be taken to prevent their escape. I enquired of the manager if any change had been made in this direction, and he referred me to Mr. Harvey for information on this point. As on every other subject he gave me every possible assistance. I suppose that condensation of the vapour of which I complained has not been arranged for. This, in my opinion, ought to be done, as the escape is, I am told, of daily occurrence, and could be accomplished with little expense and without interference with the process.

Messrs. Callender have adapted to all their existing boiling pans a cover so arranged as by means of a large outlet pipe to conduct the vapours immediately into the furnaces below the pans. The arrangement in the first pans they altered appeared to me to be imperfect, inasmuch as the volatile matters were led above the fire bars instead of below them, the effect being to allow them to pass practically unchanged into the chimney in place of being destroyed by passing through the heated fuel. I pointed out this defect at my last visit, and the two other pans have been fitted as suggested. The works were not in operation, and I am therefore unable to say if the destruction of the noxious vapours is absolutely effected. The report of your surveyor after having seen the boiling going on, is however satisfactory, both as regards boiler house and a new process for impregnating cloth with their bitumen, which, when I saw the means provided for the purpose, seemed likely to produce a good deal of vapour and to cause annoyance.

The passage of the cloth into water directly it issues from the hot bitumen as described, will certainly, to a great measure, prevent the escape of this vapour.

The condition of the district is certainly greatly improved, and when Messrs. Proctor and Bevington's machinery is complete, and alterations are made in the retiring process at Sir Charles Price and Co.'s works, it is to be hoped the factories on the south side of the river may be worked without annoyance to the neighbourhood.

I am, &c.
(Signed) G. H. Ogston.

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*Sanitary.*

To the Erith Local Board.

High Street, Erith,
November 1881.

Gentlemen,

From instructions received at the last Board meeting I have inspected the factories on this side of the Thames five different days, at different times each day. Messrs. Callendar and Sons commenced boiling on Monday, October 31st with the boilers that had been altered after discontinuing more than two months, and have done so since up to date, except on Saturday, on which day they do not boil, a great improvement is visible since notice was first given them, but the smell is not quite disposed of. Messrs. Price and Co.'s works I have not examined internally, only going round to ascertain the smells that arise therefrom; they are less than they were; the smell from ditch is also better, but not what it should be. Messrs. Berger, Spence, and Co. are doing but little, that is, grinding metallic ore for paint and melting small quantities of their metal for statuettes, busts, &c. for experiments. No disagreeable smell arises from these works. Messrs. Collins and Co. have received a large quantity of lime foots from tan yards for making into manure, this is mixed with lime and sulphuric acid, which evolves a non-pleasant smell, there is also drainage from these and the adjoining works; a quantity of stagnant water when stirred is very offensive. Messrs. Proctor and Bevingtons did not boil from October 20th until November 1st, and continued on November 1st, 3rd, and 4th, the refuse from concentrator is passed out in a semi-liquid state, and cannot be wheeled away until the next day; this, and having to dry it on kilns, allows a bad smell to escape, the alterations that have been made in the process of boiling have very much decreased the smell in that part of the work. Messrs. Johnstone's are at present using the old machinery that was fixed in their factory for drying and grinding the refuse from some of the London warehouses, the smell of which at present is not offensive and does not travel.

I observed a very offensive smell in my house on Sunday last about 5.30 p.m., which must have arisen from Messrs. Price's works or from works on the Essex side, as no other works in this district were at work; I also think from the opportunities I have of watching the manufactories on the Essex side of the river the most offensive smell arises therefrom, the smell from the river itself when the wind is favourable can scarcely be observed, which is very different to what it was some six weeks since.

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Local Government Board,
Whitehall, S.W.,
Sir, 26th October 1881.

I am directed by the Local Government Board to transmit you herewith, for the consideration of the Erith Local Board, a copy of a letter which Mr. J. D. Lee has addressed to the Board renewing his complaint as to

the nuisances caused by noxious vapours emanating from manufactories in the neighbourhood of Erith, and adverting to your letter of the 25th April last I am to request that the Board may be furnished with the observations of the local board upon this subject.

I am, &c.
(Signed) Walter J. Sendall,
Assistant Secretary.

To F. Parish, Esq.,
Clerk to the Erith Local Board,
Erith, Kent.

To the Secretary of the Local Government Board,
Whitehall, London.

The Oaks, Belvedere Park,
Sir, October 17th 1881.

Referring to your letter of 5th May 1881, enclosing a reply received from the local board, bearing date of the 29th of April, I now regret to say that although the manufacturers have had a reasonable time for improving their machinery, that on my return to the Oaks after six months absence, the offensive vapours are as bad as when I left, and I can see no remedy but having at the age of 70, with my wife, to sacrifice my property and leave the neighbourhood. My neighbour who is on the Board is of the same mind, for he is powerless at that Board, the manufacturing element being too strong to carry out any suggestion of his.

During my absence a dear friend in the line of stench had occasion to call in Sir William Jenner on a case of gastric fever. On Sir William's arrival he enquired what the horrid smell was, and on being informed it was from the factories, his remark was "Death, death; get out of it as soon as possible." The poor fellow is out of it now—passed away—and his sister down with a similar attack.

I am aware that Mr. Ogston is claiming credit for having in a degree stopped the stench. I have to say that all day Sunday and again this morning it is dreadful, and I now learn that the Board have granted a license to a man to make manure from the condemned fish from Billingsgate, within half a mile of Erith, although at the same time it is proposed to put up a fever hospital on a piece of ground belonging to a member of the local board. Under these circumstances I must again throw myself upon the protection of the Local Government Board.

I have, &c.
(Signed) J. D. Lee.

Walter Sendall, Esq.

*Sanitary.*

To the Erith Local Board.

Offices, High Street, Erith,
Gentlemen, 13th September 1881.

Eight open privies in Claremont cottages have been panned and trapped, six other privies nearly adjoining are in a similar state as when last reported.

The manufactories on this side of the Thames are working in a satisfactory manner. Messrs. Proctor and Bevington have had the connection of pipes to the condenser made good, which has caused a beneficial effect, the others are in a similar manner as when last reported.

On Thursday September 8th a very offensive smell arose from the river, worse than I ever noticed.

To the Erith Local Board.

Pier Road, Erith,
Gentlemen, 20th December 1881.

I have to report that there are several slight cases of whooping cough in the parish among children.

I have cautioned those that have come under my notice to keep away from school for a time.

The parish is, I believe, perfectly free from every other infectious disease.

The smell from Price and Co.'s factory was very bad indeed on Tuesday, December 13. The wind being N.W., blew the effluvia straight across the town of Erith, and I smelt it even at the Saw Mills, Crayford.

I drew the attention of some people to it, who all condemned it as being most offensive and sickly.

Yours, &c.
F. Parish, Esq. (Signed) Fredk. B. Jessett.

To the Erith Local Board.

Pier Road, Erith, Kent,
Gentlemen, January 25th, 1882.

There have been 114 deaths during the year 1881. This is an extraordinary diminution in number as compared with any previous year. Thus in the year 1878 there were 147 deaths: 1879, 165, and 1880, 161, or taking the three districts of Erith, Belvedere, and Northumberland Heath and the public institutions, the number of deaths are as shown in the following table:—

| District. | 1878. | 1879. | 1880. | 1881. |
|---|---|---|---|---|
| Erith | 68 | 73 | 60 | 54 |
| Belvedere | 55 | 49 | 61 | 38 |
| Northumberland Heath | 12 | 15 | 12 | 14 |
| Cottage Hospital | — | 6 | 4 | 9 |
| Royal Alfred Institution | — | 16 | 12 | 4 |
| Violence | 7 | 6 | 12 | 6 |

The above table shows a universal improvement in the health of the parish; no one district fares better than its neighbour, and although Northumberland Heath maintains about the same number of deaths, yet it must be remembered that this district has been built upon more in proportion than any other.

There has been a total absence of any epidemic. There has not been a single death registered from either scarlet fever, measles, whooping cough, or any of the continued fevers, while there has been only one death from smallpox.

It will be observed that the death-rate is very much less than in any previous year, the rate being this year only 11·1 in 1,000, whereas in the year 1879 it was 13·7 in the 1,000; 1880, 14·63; these figures however were fallacious, as I allowed for a larger population than there really was.

The cases of typhoid fever which occurred at the Northumberland Heath district were confined to one family, and with the exception of the young man who died in the latter part of the year 1880, they all made a good recovery.

Of the few cases of scarlet fever that occurred in the Belvedere district, all did well; the disease was of a very mild type and limited to one or two families, thanks to the great precaution taken, no spread of this disease occurred. There has been one death during the year from diphtheria in some cottages situated behind West Street. These cottages are supplied by a well for drinking water, which well is in dangerous proximity to the closets and cesspool. The water was however twice analysed by the public analyst and reported fit for drinking purposes. The well therefore, much against my will, still exists. A few wells have however been closed during the year, and water laid on from the company's main. I find in Erith wells have been closed in Pier Road, Crayford Road, behind the King's Head, Bexley Road, West Street, Queen's Road, and Lesney Farm; to all of these water has been laid on from the West Kent Waterworks Company's main. In Belvedere wells have been closed in Cheshunt Road, Standard Road, Picardy Road, and the Royal Alfred Institution, the company's water being substituted.

A number of new cottages have been built during the year, viz., in Erith 16, Belvedere 18, and the new police station, Northumberland Heath, 19 new cottages have been added making 53 in all. Many of these have been drained into the Erith drainage, while the others have good cesspools formed according to the bye-laws. The scheme for draining the whole parish is still in embryo, and there is a possibility of the Metropolitan outfalls being carried further down the river, and as the present system appears under your supervision to answer fairly well, I cannot urge upon you to take any very active steps in the matter. While upon this topic I was most pleased to see that your Board fully entered into the vital importance of endeavouring to enforce the Metropolitan Board to do something to abate the

App. A.J.

abominable nuisance they are causing by pumping the enormous amount of sewage into the river at Crossness and Barking, the greater part of which must of necessity be deposited upon the banks of the river, as it has proved beyond dispute that the sewage that is pumped out of the river at the commencement of the ebb tide can never get lower down the river than Gravesend, while that which is pumped out later on the ebb can get no further than your parish before it is met by the flood tide to be carried up the river to Woolwich, Blackwall, and even London Bridge, the sewage that had been pumped out earlier on the ebb being returned to our shore from Gravesend, Greenhithe, and Northfleet.

Much no doubt will be made by the advocates of the present system of disposing of the sewage of London at the two outfalls of the excessively low death-rate of this district and also of the nearly total absence of all fevers; but, gentlemen, there are few among you who do not remember the vile stench emitted from the mud on our shores at low tide during the excessive heat of last summer. Without exception, I will venture to assert all the yachtmen who lay off our town will agree as to the filthy masses of black sewage washed backwards and forwards by their yachts during that excessive heat and of the stench emitted from the river generally. It was a source of some surprise to me that fever of the most virulent type was not manifest among the crews of these yachts, but thankful must we be to think we passed through this summer without any such outbreak; but we cannot but look with a wholesome dread at the summer to come, and I should not be doing my duty if I let this subject pass without urging upon you the great importance of your taking active steps to help and co-operate with those gentlemen who are moving in the matter in the hopes that some effectual means will be adopted to abate this gigantic and ever-increasing nuisance. I would even go further and say that the Local Government Board will be failing most egregiously in their duty to all the inhabitants of the different districts on either side of the Thames below London Bridge if they do not institute a most searching inquiry into the whole matter. It is not at this time of the year, gentlemen, that we are likely to suffer, as now, on account of the large proportion of storm water mixed with the sewage, it is so diluted that possibly little harm is likely to accrue; moreover, the temperature is such as not to encourage fermentation or chemical decomposition, but it is in the summer when the concentrated essence is thrown out of these two outfalls. We are told the Metropolitan Board intend enlarging the tanks at the outfalls; is this likely to improve matters? I say, emphatically, No. The only possible use of these large tanks will be to prevent the bursting of their sewers and the flooding of the property around Lee and other localities that have of late years been deluged with sewage during heavy rains and storms. But we do not want to go further when we read that the report of the London Sanitary Committee on Thames outfalls contains, besides statements such as I have mentioned above, a description of sample extracted from the river at various places and chemically tested. Without going into much detail, it may be mentioned that samples taken off Barking contained one fifth of their bulk of sewage.

The total solid residue was in this case 831 grains per gallon from one sample and 570 from another, the loss on ignition being set down at 375 in the first case, and the total of chlorine per gallon amounting to 260 and 280 grains respectively.

Another very interesting and highly instructive fact is that which shows the increase in 10 years on the gross amount of liquid discharged into the river from the two outfalls. The increase goes on year by year at a pretty steady rate; and the total rises from 17½ million gallons in 1863 to over 27 million in 1878 from Crossness outfall, while at Barking the increase is still more remarkable, the advance being from considerably under 13 millions in 1868, and more than 30 millions in 1878. That this state of things is a disgrace to the nation every one will, I think, agree, and if allowed to continue this huge cesspool between Blackwall and Gravesend will be worse than that which existed at Westminster years ago, and will undoubtedly, if not done away, bring among all our shipping an epidemic which will not be surpassed by the great cholera epidemic which existed in London before the drainage was carried to its present outlets.

*Noxious Vapours*

Much has been done during the year to abate the nuisances arising from the escape of noxious vapours from the factories along the river. Messrs. Callander, I think, have succeeded tolerably well in doing away with any nuisance arising from their works. Messrs. Price & Co. have introduced some improvements, but they still, during one process of the manufacture, emit a most offensive effluvia; this will, I hope, before long be overcome and the nuisance therefrom abated. Messrs. Collins and Bevington have not yet succeeded in stopping the nauseating smells being emitted from their works, but they have made many improvements, and doubtless they will succeed in effectually stopping any vapours escaping which will be a nuisance to the neighbourhood. A new manufactory has been started by Messrs. Johnston, just above Messrs. Bevington's; this factory threatened to be a great nuisance, but, thanks to the precautions taken by your Board, I do not think any great inconvenience is likely to arise from this firm. The gasworks often emit very disagreeable fumes from the lime which is thrown out of these works after it has been used to purify the gas. I think more care should be taken by the company to avoid this nuisance. During the coming year the new Alkali Act comes into force, and doubtless an inspector will be appointed for this district to watch the different factories, and stop any manufacture which may be a nuisance to the neighbourhood.

Believe me, &c.
(Signed) F. B. Jessett, F.R.C.S.

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To the Secretary, The Local Board.

February 22nd, 1882,
Bastal Hill School,
Abbey Wood, Kent.

Sir,

Yesterday afternoon the smell from the marshes was intolerable.

This evening we were visited by a worse stench than I can remember. Directly I discovered it I had to rush and close every aperture looking north.

When it began I cannot say. It had made its way into my study at 7.15 a.m., and when I went out to investigate, I found the passages full of it, and it was almost impossible to stand at my front door.

By 7.25 it had sensibly diminished.

Will you kindly call the attention of the Board to this statement?

I am, &c.
(Signed) Frederic Wood.

P.S.—I have just seen the postman, and he tells me this stench had lasted quite an hour.

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Belvedere, February 23, 1882.

Inspector of Factories on the Riverside, Belvedere Marshes.

In consequence of a very disagreeable stench at Belvedere Mr. Strickland requested me to find out what factory it came from. In tracing it I found it came from Messrs. Proctor and Bevington. I walked round the whole of the factories on the marshes, and the wind was bringing the smoke from the factories on the other side of the river, but I found no bad stench from any but Proctor and Bevington's.

4 o'clock p.m.
Wind N.E.

James Blake.

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The Tower, Belvedere Park,
February 28, 1882.

My dear Sir,

I regret the state of my health has and will prevent my attending the meetings of the Erith Local Board for some time to come.

On the 23rd inst., and some days previous, the stench from the factories was at times awful; on the latter it was so bad that I asked Mr. Strickland to send the person who had previously been employed to watch the factories; he states that the stench came from Messrs Proctor and Bevington's. I thought the Government Surveyor would have been at Erith last month. If I do not hear from you that he is coming very shortly I must write to the Government Local Board, and remain

Yours truly,
Robt. V. Asser.

Wm. Anderson, Esq.,
Chairman,
Erith Local Board.

Utrecht House, Abbey Wood,
March 17th, 1882, 6.45 p.m.

Dear Sir,

I think it right to draw your attention to the fact that there is now a most noxious smell overhanging this district. I have just been on Bostal Common, where the stink was so bad that it was impossible for me to continue my walk. I think that what I now complain of is about as bad a smell as anything we have ever had. There is but very little wind, and what there is, is coming from the north-west.

Kindly bring this communication to the attention of the Local Board.

I am, &c.
Geo. A. Cape.

F. Parish, Esq.

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Annual Report for the year 1882.

To the Erith Local Board.

Erith House, Erith, Kent,
January 1st, 1883.

Gentlemen,

At the early part of the year there were several cases of small-pox in the parish, all of which had been imported, the sufferers having contracted the disease either in London or Woolwich. Strict precautions, however, were taken, and the disease was in each case confined to the family in which it had occurred; one death, however, occurred in a child, the others all made a good recovery.

Scarlet fever was also prevalent in the early part of the year, and two deaths were registered. Strict antiseptic precautions were taken and the disease did not spread to any appreciable extent.

Whooping-cough was very prevalent throughout the whole parish in the spring, and caused a rather large number of deaths among infants; as the summer advanced, however, the disease gradually subsided.

During the latter part of the year there has been a very universal epidemic of measles, which, however, was of a mild type, and although several infants succumbed to the disease, yet it never assumed such proportions as to cause me to advise the school board to adopt any very stringent measures.

During the year there have only been a very few isolated cases of typhoid fever; one case, however, died from relaxation of the bowels following the fever.

A few more wells have been closed during the year, and there now remain only a very few in the parish, and for the health of the district the sooner they are closed he better.

There has been a good deal of building in the district during the year; new shops have been erected round the public hall, and some good cottages have been built in West Street; at Northumberland Heath a large number of very superior cottages have been erected, while at Belvedere some very excellent villa residences have been built, as well as many good cottages in Leather Bottle Road and Harrow Road. As these have been built according to the Board's byelaws, and under tke supervision of your inspector, it is fair to presume that the sanitary arrangements of all these houses have been attended to in first-rate manner.

The action your Board with other influential company and individuals have taken respecting the metropolitan outfalls has borne good fruit, a Royal Commission having been granted this body of gentlemen; have sat now several times, and most voluminous evidence has been given, all pointing to the terrible nuisance the pumping of the sewage into the river at Crossness and Barking causes; and I have very little doubt that evidence of such weight and importance will be the means of causing, at no very distant date, the Metropolitan Board to do something to abate this ever-increasing nuisance.

I wish I could congratulate you upon the results of your action in endeavouring to do away with the vile and nauseating stenches emitted from the factories on the river sides, both on this side of the river and on the Essex shore. The stenches emitted from these factories on many occasions during the year have exceeded, if it were possible, those of previous years, yet, as far as I can discover nothing has been done for a length of time to strive and abate the nuisance. I would urge upon you, however, in the coming year to direct your attention in this direction, as these smells are the means of detracting from the value of property in this parish, and apart from that I believe it to be indirectly injurious to health. It is true Mr. Ogston has been instructed to visit these factories; but without it is with a view of his collecting evidence to prosecute the delinquents, I contend you are doing the very thing by his visits which would strengthen the hands of the manufacturers, as if he passes their machinery as being the best, in his opinion, to abate the nuisance, I fear, if it came to active measures being taken, you would find, he acting as your representative having passed the machinery, would tell very much against you. Doubtless, however, during the coming year you will direct your attention to this matter.

App. A.J.

The disinfecting shed has been fitted and erected during the year. This is a subject on which you are to be congratulated, as if any epidemic should arise now you have a place in which all the bedding, clothing, &c. can be most thoroughly and efficiently disinfected, and I trust you will in years to come insist in all cases of fever, small-pox, and other infectious diseases that all the clothing, bedding, &c. shall be taken to this disinfecting shed and thoroughly fumigated and baked.

No doubt the Board that has seen its way to erecting this most essential building will ere long see the desirability of following up their efforts by advising the erection of a small infectious diseases hospital.

I would also direct your attention to the state of the public mortuary. I some time ago suggested that a proper table with a slate slab should be placed there, but up to the present time the old table still remains there, which is a disgrace.

I would also suggest that your inspector be instructed to visit this place from time to time and see that it is kept clean and in proper order; also a supply of towels, soap, pails, basins, should be kept there, as well as some weights and scales. I mention this last, as the coroner often in the course of his inquiries requires to have the weight of the different organs of the body when it might be of the greatest importance in enabling the jury to arrive at a true verdict.

I was sorry to find the annexation of the Arthur Street district to this urban district had been abandoned, as I look upon this part of Crayford parish as a most fruitful source of fevers to Erith that can be. It is badly drained; there are still wells open which are in dangerous proximity to cesspools. The new cottages erected there are, many of them, disgracefully built; in fact I know of few places that require more looking after than this district, and I am quite sure, if you could see your way to annexing it under your government, that much may done not only for the poor people living there, but also in all probability in preventing disease being imported into your own district.

The health of the parish generally has not been so good as last year, but better than in the two preceding years. The total number of deaths has been 158 as against 114 in 1881, and 165 in 1880, or taking the different districts, as I have done in former years, it is as follows:—

| District. | 1879. | 1880. | 1881. | 1882. |
|---|---|---|---|---|
| Erith - - - | 73 | 60 | 48 | 59 |
| Belvedere - - - | 49 | 61 | 33 | 52 |
| Northumberland Heath - | 15 | 12 | 14 | 20 |
| Cottage Hospital - - - | 6 | 4 | 9 | 5 |
| Royal Alfred Institution - | 16 | 12 | 4 | 5 |
| Violence and Inquests - | 6 | 12 | 6 | 17 |

The death-rate for the year is 15·8 per thousand; this is in excess of the previous year. I have always allowed for an increase in the population rather in excess of what the last census proved to be correct. This year, however, I have I believe allowed scarcely a sufficient increase, as on account of the number of men employed at Messrs. Shuttleworth and Chapman's, and the excess of births over deaths, I think the population now must be more than 10,000. The number of births this year has been 348 as against 321 in 1881.

As this is the last report I shall have the honour of making to you in my capacity as medical officer of health to your district, allow me to thank you for the courtesy you have always shewn, and for the kind manner in which you have listened to and endeavoured as far as possible to carry out any suggestions I might have thought right to place before you. If at any time feeling strongly upon any subject I may have expressed myself too freely I am sure you will understand my reason for doing so was that I always have had and always shall have the welfare of Erith at heart.

Believe me, &c.
Fredk. B. Jessett, F.R.C.S.E.,
Med. Off. Health.

App. A.L.

## APPENDIX A.L.

*Put in by Mr. Chatterton, 23rd May* 1883. *See Q.* 13,072.

Gaugings of the River Thames at Seething Wells in the Months of February, March, April, and May 1882.

| Date. | Above S.L. | | Discharge in Gallons in 24 Hours. |
|---|---|---|---|
| 1882. | Feet. | Tenths. | |
| February 1 | 1 | 0 | 766,800,000 |
| ,, 2 | 0 | 9 | 738,408,000 |
| ,, 3 | 0 | 6 | 653,232,000 |
| ,, 4 | 0 | 8 | 710,016,000 |
| ,, 5 | 0 | 9 | 738,408,000 |
| ,, 6 | 0 | 7 | 681,624,000 |
| ,, 7 | 0 | 7 | 681,624,000 |
| ,, 8 | 0 | 7 | 681,624,000 |
| ,, 9 | 0 | 7 | 681,624,000 |
| ,, 10 | 0 | 5 | 624,840,000 |
| ,, 11 | 0 | 6 | 653,232,000 |
| ,, 12 | 0 | 8 | 710,016,000 |
| ,, 13 | 0 | 6 | 653,232,000 |
| ,, 14 | 0 | 6 | 653,232,000 |
| ,, 15 | 0 | 7 | 681,624,000 |
| ,, 16 | 1 | 2 | 832,680,000 |
| ,, 17 | 1 | 8 | 1,052,610,000 |
| ,, 18 | 1 | 4 | 898,560,000 |
| ,, 19 | 1 | 4 | 898,560,000 |
| ,, 20 | 1 | 0 | 766,800,000 |
| ,, 21 | 0 | 4 | 601,122,000 |
| ,, 22 | 1 | 1 | 799,740,000 |
| ,, 23 | 1 | 2 | 832,680,000 |
| ,, 24 | 0 | 7 | 681,624,000 |
| ,, 25 | 0 | 7 | 681,624,000 |
| ,, 26 | 0 | 9 | 738,408,000 |
| ,, 27 | 1 | 6 | 971,870,000 |
| ,, 28 | 1 | 5 | 931,500,000 |
| March 1 | 2 | 4 | 1,319,310,000 |
| ,, 2 | 3 | 5 | 1,948,000,000 |
| ,, 3 | 3 | 6 | 2,016,760,000 |
| ,, 4 | 3 | 1 | 1,697,360,000 |
| ,, 5 | 2 | 8 | 1,527,140,000 |
| ,, 6 | 2 | 6 | 1,419,580,000 |
| ,, 7 | 2 | 4 | 1,319,310,000 |
| ,, 8 | 1 | 7 | 1,012,240,000 |
| ,, 9 | 1 | 4 | 898,560,000 |
| ,, 10 | 1 | 0 | 766,800,000 |
| ,, 11 | 1 | 2 | 832,680,000 |
| ,, 12 | 1 | 0 | 766,800,000 |
| ,, 13 | 0 | 9 | 738,408,000 |
| ,, 14 | 0 | 8 | 710,016,000 |
| ,, 15 | 0 | 9 | 738,408,000 |
| ,, 16 | 0 | 8 | 710,016,000 |
| ,, 17 | 0 | 7 | 681,624,000 |
| ,, 18 | 0 | 8 | 710,016,000 |
| ,, 19 | 0 | 7 | 681,624,000 |
| ,, 20 | 0 | 5 | 624,840,000 |
| ,, 21 | 0 | 7 | 681,624,000 |
| ,, 22 | 0 | 6 | 653,232,000 |
| ,, 23 | 0 | 4 | 601,122,000 |
| ,, 24 | 0 | 8 | 710,016,000 |
| ,, 25 | 0 | 7 | 681,624,000 |
| ,, 26 | 0 | 8 | 710,016,000 |
| ,, 27 | 1 | 2 | 832,680,000 |
| ,, 28 | 1 | 0 | 766,800,000 |
| ,, 29 | 1 | 0 | 766,800,000 |
| ,, 30 | 0 | 7 | 681,624,000 |
| ,, 31 | 1 | 0 | 766,800,000 |
| April 1 | 0 | 6 | 653,232,000 |
| ,, 2 | 0 | 5 | 624,840,000 |
| ,, 3 | 0 | 5 | 624,840,000 |
| ,, 4 | 0 | 6 | 653,232,000 |
| ,, 5 | 0 | 4 | 601,122,000 |
| ,, 6 | 0 | 7 | 681,624,000 |
| ,, 7 | 0 | 5 | 624,840,000 |
| ,, 8 | 0 | 6 | 653,232,000 |
| ,, 9 | 0 | 4 | 601,122,000 |
| ,, 10 | 0 | 3 | 577,404,000 |
| ,, 11 | 0 | 3 | 577,404,000 |
| ,, 12 | 0 | 4 | 601,122,000 |
| ,, 13 | 0 | 3 | 577,404,000 |
| ,, 14 | 0 | 7 | 681,624,000 |
| ,, 15 | 1 | 0 | 766,800,000 |
| ,, 16 | 0 | 6 | 653,232,000 |
| ,, 17 | 0 | 4 | 601,122,000 |
| ,, 18 | 0 | 1 | 529,968,000 |
| ,, 19 | 0 | 4 | 601,122,000 |
| ,, 20 | 0 | 4 | 601,122,000 |
| ,, 21 | 0 | 4 | 601,122,000 |
| ,, 22 | 0 | 1 | 529,968,000 |
| ,, 23 | 0 | 8 | 710,016,000 |
| ,, 24 | 1 | 7 | 1,012,240,000 |
| ,, 25 | 1 | 5 | 931,500,000 |
| ,, 26 | 2 | 0 | 1,133,350,000 |
| ,, 27 | 3 | 1 | 1,697,360,000 |
| ,, 28 | 2 | 7 | 1,473,360,000 |
| ,, 29 | 2 | 7 | 1,473,360,000 |
| ,, 30 | 3 | 0 | 1,634,700,000 |
| May 1 | 3 | 1 | 1,697,360,000 |
| ,, 2 | 2 | 8 | 1,527,140,000 |
| ,, 3 | 2 | 6 | 1,419,580,000 |
| ,, 4 | 2 | 4 | 1,319,310,000 |
| ,, 5 | 2 | 8 | 1,527,140,000 |
| ,, 6 | 2 | 4 | 1,319,310,000 |
| ,, 7 | 2 | 8 | 1,527,140,000 |
| ,, 8 | 2 | 4 | 1,319,310,000 |
| ,, 9 | 1 | 7 | 1,012,240,000 |
| ,, 10 | 1 | 3 | 865,620,000 |
| ,, 11 | 1 | 3 | 865,620,000 |
| ,, 12 | 1 | 1 | 799,740,000 |
| ,, 13 | 0 | 8 | 710,016,000 |
| ,, 14 | 0 | 8 | 710,016,000 |
| ,, 15 | 0 | 6 | 653,232,000 |
| ,, 16 | 0 | 5 | 624,840,000 |
| ,, 17 | 0 | 5 | 624,840,000 |
| ,, 18 | 0 | 5 | 624,840,000 |
| ,, 19 | 0 | 3 | 577,404,000 |
| ,, 20 | 0 | 3 | 577,404,000 |
| ,, 21 | 0 | 4 | 601,122,000 |
| ,, 22 | 0 | 6 | 653,232,000 |
| ,, 23 | 0 | 4 | 601,122,000 |
| ,, 24 | 0 | 4 | 601,122,000 |
| ,, 25 | 0 | 8 | 710,016,000 |
| ,, 26 | 0 | 8 | 710,016,000 |
| ,, 27 | 0 | 9 | 738,408,000 |
| ,, 28 | 1 | 0 | 766,800,000 |
| ,, 29 | 0 | 9 | 738,408,000 |
| ,, 30 | 0 | 4 | 601,122,000 |
| ,, 31 | 0 | 2 | 553,686,000 |

Mean flow, 833,115,000 gallons per diem, or 92,568 cubic feet per minute, from 1853 to 1880.

## APPENDIX B.S.



*Put in by Dr. Collingridge.* *See QQ. 6764 and* 16,799.

Port of London Sanitary Offices,
King William Street, Greenwich, S.E.,
22nd July 1880.

Extracts from Monthly Report of the Medical Officer of Health, Port of London, affecting West Ham Pumping Station in Bow Creek.

Perhaps the most important event in connexion with the river, so far as the health of our great city is concerned, has been the publication of the report and determination of Captain Douglas Galton and Mr. Frederick J. Bramwell, the arbitrators appointed by the Metropolitan Board of Works and Conservators of the Thames to settle the question of obstruction to navigation by the deposit of mud banks caused by the outfalls at Barking and Crossness.

After a lengthy and exhaustive inquiry they determined—

1. That the navigation in the Barking and Halfway Reaches far from being injured by the sewage outfalls is actually in a better condition now than it was before those outfalls were opened;
2. That each of the three banks, viz., Barking, Margaretness, and Crossness, has arisen from the dredging operations of the Thames Conservators themselves in obedience to well-known laws;
3. That the river always contains a large quantity of suspended matter, of which the major amount is mineral, and to which the metropolitan sewers contribute but a very small proportion;
4. That the three banks have been formed from the suspended solid matter;
5. And, therefore, that the three banks cannot be said, in the sense of the Act of 1870, to have arisen from the flow of the sewage at the outfalls, and that consequently the Metropolitan Board of Works should not be called upon to remove them.

Thus this determination has very decidedly settled for many years to come the question of position of these outfalls, at any rate so far as an interference with the navigation is concerned.

The question, however, of other outfalls above these is still a serious one, and likely to give trouble to the river authorities in the future. One which has come more particularly under our notice recently is the West Ham Pumping Station, situated about a mile up Bow Creek.

The attention of this authority was called to the outfall by a letter from a barge owner living a short distance below the station, in which he stated that for some time there had been a very great nuisance in consequence of the sewage finding its way down the creek and being deposited on the banks, whence it gave rise to an extremely offensive smell, and that on account of the foul odour and its effects he was unable to men in his employ for any length of time.

Under these circumstances, I felt it my duty to make a careful inspection of the creek. This was done on the 4th June at high tide, at which time the water appeared fairly good, though somewhat turbid. There was no perceptible odour of sewage, and obviously nothing could be seen of the alleged deposits.

I visited the pumping station, and was informed by the manager that the sewage was treated by precipitation with lime; that after settlement the supernatant fluid was allowed to run into the river.

The sludge thrown down is allowed to dry, and is then compressed by powerful machinery into flat discs.

The rate of flow into the creek is about 4,000 gallons per minute, and as this continues for 16 or 18 hours a day, it must necessarily be continued at all states of the tide.

On the 17th, a second visit was made at low water. It was then found that a large deposit of undoubted sewage, mixed with the ordinary river mud, was thrown upon the banks in certain parts. When this is removed by barge builders from their hards it is returned at the next tide. At the time of inspection there was a full stream issuing from the pumping station sluice, which smelt very strong, was of a dark colour, and in which were floating masses of fæcal matter.

On the banks surrounding the outfall were large masses of rags, paper, and other materials usually found in sewage. Samples both of mud and water were taken, and have been examined.

In the two or three cases of illness which have occurred recently, said to be due to the noxious odour, the symptoms were similar, viz., vomiting and diarrhœa. The offensive character of the mud is said to be on the increase, and must of necessity prove more injurious during hot weather.

It should also be mentioned that there are a number of privies and other small outfalls emptying into the creek. Of these a complete list has been made, and your medical officer will call upon the proper authorities to remove them.

## APPENDIX B.T.



*Put in by Captain Burstal.* *See Q.Q. 6652 and* 16,799.

Thames Conservancy.

Return of Westward Hand and Steam Dredging Licenses issued from 1863 to 1882, and Eastward Hand and Steam Dredging Licenses issued from 1865 to 1882.

| Westward (above London Bridge). | | | | | | Eastward (below London Bridge). | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Date. | Number of Licenses. | Amount. | | | Steam Dredgers. | Date. | Number of Licenses. | Amount. | | | Steam Dredgers |
| | | £ | s. | d. | £ s. d. | | | £ | s. | d. | £ s. d. |
| 1863 | 53 | 511 | 3 | 7 | 320 0 0 | | | | | | |
| 4 | 43 | 415 | 5 | 0 | 166 13 4 | 1st August to 31st | | | | | |
| 5 | 43 | 483 | 0 | 4 | 150 0 0 | December 1865 | 94 | 301 | 10 | 0 | — |
| 6 | 49 | 547 | 10 | 0 | 216 13 4 | Year 1866 | 103 | 639 | 5 | 0 | — |
| 7 | 37 | 398 | 0 | 0 | 196 12 1 | 7 | 131 | 452 | 3 | 2 | — |
| 8 | 32 | 349 | 11 | 8 | 16 13 4 | 8 | 114 | 382 | 5 | 0 | — |
| 9 | 37 | 364 | 15 | 0 | — | 9 | 128 | 418 | 12 | 0 | — |
| 70 | 36 | 363 | 0 | 0 | 100 0 0 | 70 | 91 | 315 | 4 | 0 | — |
| 1 | 26 | 245 | 0 | 0 | 50 0 0 | 1 | 107 | 329 | 8 | 6 | 158 6 8 |
| 2 | 30 | 262 | 0 | 0 | — | 2 | 119 | 394 | 8 | 0 | 83 6 8 |
| 3 | 27 | 286 | 17 | 6 | — | 3 | 92 | 296 | 15 | 2 | — |
| 4 | 28 | 263 | 0 | 0 | — | 4 | 87 | 282 | 7 | 10 | 200 0 0 |
| 5 | 26 | 240 | 16 | 8 | — | 5 | 105 | 315 | 9 | 4 | 326 0 0 |
| 6 | 26 | 231 | 15 | 0 | — | 6 | 118 | 349 | 12 | 10 | 166 13 4 |
| 7 | 39 | 319 | 3 | 8 | — | 7 | 130 | 378 | 4 | 10 | 158 6 8 |
| 8 | 48 | 406 | 5 | 0 | — | 8 | 130 | 390 | 4 | 0 | 349 10 8 |
| 9 | 53 | 526 | 11 | 8 | — | 9 | 128 | 415 | 6 | 0 | 256 7 4 |
| 80 | 44 | 416 | 10 | 0 | — | 80 | 105 | 307 | 17 | 8 | 177 13 0 |
| 1 | 54 | 495 | 5 | 0 | — | 1 | 140 | 436 | 12 | 6 | 214 10 0 |
| 2 | 43 | 415 | 13 | 4 | — | 2 | 128 | 365 | 11 | 0 | 116 13 4 |
| | 774 | 7,541 | 3 | 5 | 1,216 12 1 | | 2,050 | 6,771 | 16 | 10 | 2,207 7 8 |

App. C.C.

# APPENDIX C.C.

List of Witnesses who have not yet been called.

*See conclusion of Forty-sixth Day's Proceedings.*

(A.) By the General Committee.

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| Charles Stirt Milnes | Coal Exchange | Coal merchant | General increasing bad state of the river; also as to barges and steamers being sunk. |
| C. Umfreville | Ingress Abbey, Greenhithe. | Gentleman | As to increasing bad state of the river in his neighbourhood. |
| William Lee | Manager, Messrs. Green, Blackwall. | Ship builders | As to the increased bad state of vessels they raise which have been sunk in the river between Blackwall and Gravesend. |
| Alfred Henry Keep | Greenhithe | Barge owner and freeman of Waterman Company. | Do. do. do. |
| W. H. Sandford | Gravesend | Trinity pilot | As to the foul state of the river when coming up with ships, and its increase. |
| Frederick Paterson | Do. | Do. | Do. do. do. |
| Charles Thomas | "Hercules" Dredger, Purfleet. | Engineer | As to increasing bad state of the river at Purfleet during last 15 years. |
| John Jewett | "Goliah" Dredger, Purfleet. | Do. | Same as last, but knew the river as pleasant before the outfalls. |
| James Perkins | Do. | Working hand | Same as last witness, but known river for 27 years. |
| Robert Grainger | "Cornwall," Purfleet. | Carpenter | On board 23 years. Notices absence of fish and bad state of the river since the outfalls; considers it to be rapidly increasing. |
| Francis Fitzgerald | Do. | Second Officer | On board 14 years; known river well 19; that water has got very bad since outfalls; attributes attacks of typhoid to state of river. |
| Captain Wm. Scott | 6, Hindon Valley Terrace, Sunderland. | Captain of the "Erith." | Engaged on river over 30 years. Notices increase of bad smells between Gravesend and Erith; suffers nausea at times; had boat sunk in Gravesend. |
| John Edwd. Waterson | 209, East India Road, Poplar, E. | Trinity pilot | Known river 30 years well; can speak as to increasing bad state, which is unbearable at times. |
| Benjamin Starbuck | 1, Swan Yard, Gravesend. | Fisherman | Cannot now catch where used to; has to go out seawards. |
| Samuel Grant | 1, Mermaid Court, Gravesend. | Do. | Do. do. do. |
| Peter Plumb | 17, Crooked Lane, Gravesend. | Do. | Do. do. do. |
| Thomas Shuttlewood, jun. | 15, West Street, Gravesend. | Do. | Do. do. do. |
| Robert Plumb | 17, Thames Terrace, Gravesend. | Do. | Do. do. do. |
| Alfred Sharpe | 49, Rectory Place, Woolwich. | Doctor | Had cases of typhoid, which he attributes to bad state of river. |
| Henry Byers | 1, Grafton Crescent, Kentish Town. | Pianoforte manufacturer. | Ill effects of being immersed in the water near Crossness. |
| Arthur Selden Collins | Belvedere Marshes, Erith. | Foreman gluemaker | Do. do. do. |
| Alfred Wood | 30, Coal Exchange | Coal merchant | As to increasing bad state of Lower Thames since outfalls. |
| E. W. Sturge | Coal Exchange | Do. | Do. do. do. |
| Wm. Milners | Do. | Shipowner | Do. do. do. |
| John R. Jones | Do. | Do. | Do. do. do. |
| Edwd. Talbot | Church St., Rotherhithe. | Barge owner | Do. do. do. |
| E. Walton Ledger | London Corn Exchange. | Corn merchant | Do. do. do. |
| Henry Smith | Do. | Do. | Do. do. do. |
| R. J. Ardley | 60, Mark Lane | Maltster | Do. do. do. |
| J. J. Smith | Pants Wharf | Lighterman | As to action of the tide. |
| Thomas Sturdy | Corn Exchange | Corn factor | As to increasing bad state of the Lower Thames since the outfalls. |
| J. S. Walker | 1, Muscovy Court | Do. | Do. do. do. |
| R. H. Wake | 9, Crosby Square | Do. | Do. do. do. |
| John Sketon | Corn Exchange | Do. | Do. do. do. |
| J. Hewitson | Do. | Do. | Do. do. do. |
| S. H. Bowyer | 58, Old Corn Exchange. | Do. | Do. do. do. |
| J. C. Strange | Old Corn Exchange | Do. | Do. do. do. |
| Thomas Lang | 6, Lewis Place, Union Street, Woolwich. | Waterman | Do. do. do. |
| William Turnnidge | 40, Albion Road, Woolwich. | Do. | Do. do. do. |

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| James Luck - - | 33, West Street, Gravesend. | Fisherman - - | As to absence of fish from Gravesend since outfalls. |
| Edward Moon - | Do. - | Do. - - | Do. do. do. |
| William Luck - | Do. - | Do. - - | Do. do. do. |
| Edward Brown - | 9, Passenger Court, Gravesend. | Do. - - | Do. do. do. |
| George Wade - | 4, Passenger Court, Gravesend. | Do. - - | Do. do. do. |
| William Brown - | 9, Passenger Court, Gravesend. | Do. - - | Do. do. do. |
| Henry Webster - | Do. - | Do. - - | Do. do. do. |
| H. Jones - - | 19, West Street, Gravesend. | Do. - - | Do. do. do. |
| Joseph Jones - | 7, Somerset Place, Gravesend. | Do. - - | Do. do. do. |
| Elias Bourne - | 1, Melbourne Place, Gravesend. | Do. - - | Do. do. do. |

The above list consists of all the further witnesses on behalf of the memorialists whose proofs of evidence have actually been taken, but we may mention that the memorial (a print of which is hereto annexed, with the names of some of the signatories) was signed by over 14,000 people, all of whom were asked at the time of signing if they were willing, and what sort of evidence they could give, and they all expressed their willingness to give evidence if amenable at the time of its being required. The solicitors to the memorialists could, if the Commissioners think it necessary, furnish a list of all the persons who signed the memorial, all which persons, it would be seen, are those who are affected by the polluted state of the river, such as shipowners, mariners, fishermen, watermen, &c., &c.

(B.) By the Erith Local Board and other Local Authorities.

Proofs of the Evidence of the following witnesses were taken by the solicitor of the Erith Local Board before and during the sittings of the Commissioners when they were taking general evidence. These witnesses were not, however, called by counsel of the Erith Local Board under the circumstances stated by counsel to the Commission at the Eighth Sitting, on Tuesday the 28th November 1882.

Yacht Owners and Membebs of the Corinthian Yacht Club at Erith and Captains of Yachts.

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| T. Catter Gash - | Lower Park Road, Belvedere. | In Bank of England; Secretary of the C.Y.C. | Says:—Continual complaints made in respect of the foul state of mud and the impossibility of keeping yachts clean or crews healthy since outfalls opened. Has been affected many times by the bad smells from the mud, and says sewage is not carried away by the tide. That mud is covered by a black and filthy slime, and that sewage settles largely near Erith, and that there is no sign of a similar settlement in Sea Reach, at the Blyth Sand, which would be equally affected if the sewage passed it going out to sea. |
| S. Harman Sturgis - | 12, Copthall Court, Throgmorton Street, London. | Stockbroker; Vice-Commodore Corinthian Club; owner of yacht "Elsie," 35 tons. | Says:—Has been yachting for more than 15 years. Used to bathe off Erith, but cannot do so now from exceedingly putrid state of water. Smells arise from mud which are almost unbearable, and his captain, Henry Curtis, and men frequently suffer when off Erith from cholic and nausea, attributable only to impurity of the water, and smells from that and the mud, on which sewage settlement can be seen. |
| Geo. Wood - - | Coal Exchange - | — | Has been yachting on the Thames for more than 40 years. He well remembers the condition of the river before the outfalls were opened. The condition is considerably worse now than then, and has become of late years a disgrace to civilization. Is of opinion that the sewage deposits on the banks are on the increase and settling up. Finds the bottom of the yacht fouled with sewage. The steward of the Erith Yacht Club was ill in 1880, and was in Sussex County Hospital. Dr. Rutter reported he was suffering from mirage fever. During the time witness lived at Erith he noticed the stench at Crossness, and has sailed through a thick liquid sewage frequently. |

App. C.C.

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| Landseer Mackenzie | 6, Kensington Park Gardens. | Owner of the yacht "Heathen Chinee." | Has been yachting on and off for 15 years. Has noticed the water in the river become extremely dirty towards half-ebb tide, and it continues to be so till after low water, with unmistakable evidence of sewage matter. Has also noticed unmistakable evidence of sewage matter deposited on the mud. The bottoms of the yachts rapidly foul in Erith Reach. Has frequently found a slimy deposit on the sides of his boat above the water-line, which it is difficult to remove. Speaking of the river generally, says that the flood tide is decidedly the strongest. There is an eddy in Church Hole, Erith, after half-ebb, so that the tendency of the current is up the river for about eight hours out of the 12. There is a distinct difference both in the colour and smell of the water from Crossness down to Erith compared with other parts of the river. |
| H. N. Custance - | 34, Tregunter Road, Brompton. | Owner of the yacht "Venture." | Has been yachting since 1867. Has noticed a great difference in the river since the outfalls have been opened. The water has a dark sewage aspect, and has a highly objectionable smell, with black looking particles floating about the surface. The banks of the river between high and low water mark are more or less poisoned. |
| J. D. Lee, Esq. - | The Oaks, Belvedere | Owner of the "Druid." | Has been yachting for about 50 years. Has remarked the state of the river, and has no hesitation in saying it has become worse since the opening of the outfalls. Lives about a mile from the outfall; has noticed the smells are much worse in hot weather. The deposits on the banks increase every year, and are most offensive, filthy, and black. The captain of the "Druid" complains of sickness arising from the stench. |
| John Fradgley - | Greenhithe - | Owner of the yachts "Honey Bee" and "Marion." | Has been engaged in yachting 40 years. Remembers the condition of the river before the outfalls were opened, since which time the water has become infinitely worse, and at times the stench is very bad. The banks of the river are very objectionable, and the sewage deposits have increased most perceptibly. Has found the yacht's bottom foul more rapidly owing to the foulness of the water. Great discomfort is caused to his crew through the condition of the river, but no positive illness. |
| T. G. Winser - | 72, Mark Lane - | Owner of the "Sheela," "Nellie," &c. | Has been yachting for about 10 years. The nuisance from the sewage is undoubtedly growing worse every year. The water is very foul, and bubbles up at low water. The smell is worse in warm weather. A boat will foul at Erith more in a fortnight than it would elsewhere in six months, owing to the state of the water. Has been unable to sleep on board at Erith owing to the excessive smell from the river, and it is generally most unpleasant to sail in Erith Reach in the summer from the same cause. |
| G. R. Dunell - - | 5, Eyot Gardens, Hammersmith. | Owner of the yacht "Gymnotes." | For some time lived close to Erith Church and almost within a stone's throw of the river, and observed the foulness of the water; the mud flats uncovered at low water are composed of a disgusting fætid slime that can be attributable to no natural cause of the river. So nauseating is the stench from the banks, and also from the water itself in hot weather, that, as a rule, it is impossible to take any pleasure afloat in the summer. His yacht, although a fast steam launch, fouled rapidly off Erith, far more so than at any station out of the Thames. The evil state of the Thames increased year by year up to 1878; 1879 was a favourable year. Since then has abandoned the Lower Thames as a pleasure resort. |

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| Stanley A. Hicks - | South Lea House, Datchet. | Owner of the yacht "Rifleman." | Has been yatching for about 10 years. The water off Erith is in a very turbid condition, especially at low water. It is worse on warm days, and has often noticed a smell from it. Finds his yacht's bottom fouls very quickly, which he attributes to the foul state of the river. Although none of his men have been ill, has had complaints as to the smell of the water from them. |
| E. B. Tredeven - | 27, Walbrook, E.C. | —— | Has been yachting on the Thames since 1872, a good deal in canoes, so that the condition of the water was brought forcibly to witness's notice. There has been a decided change for the worse in the river since 1872. The water is strongly impregnated with sewage, and cannot be bathed in without making one sick, and the banks are covered with foul smelling slime or mud. On warm days the smell is much worse. The mud deposits on the banks have become much more objectionable, because so largely mixed with sewage; very foul gases escape. On one occasion, at about one-quarter ebb, paddled close under the Crossness outfall, and was so sickened by the sewage then that had always endeavoured to give it a wide berth since. Has often seen excrementa floating in considerable quantities on the tide. |
| William Cook - | —— | Captain of the yacht "Marana." | Witness was formerly steward of C. Y. C. at Erith, and lived with wife and three children at club house there. His wife and children were never well, and the youngest died. He then gave up situation, and became captain of the "Marana." Has almost continually through the last two summers slept on board yacht off Erith, and during that time has suffered from chronic diarrhœa and cramp pains, which he attributes to sewage. In hot weather sewage lies on surface like dirty grease, quarter inch thick, and the stench is horrible from it. It clings to the boats and spoils the paint; smells like a cesspool, and cannot be used, except just at high water for washing decks. Witness says stream is silting up through sewage deposit and nothing else, as the black deposit is not river mud, to which he has been used from his infancy. Witness says yacht owners are removing their yachts from Erith to the mouth of the Thames, to avoid the dreadful sewage stench. |
| H. Curtis - - | —— | Captain of yacht "Elsie," 35 tons. | Supports generally the proof of evidence of W. Cook and the evidence of J. G. Lee given before the Commission on the fifth day of sitting, page 17, and has suffered from sore throat and sickness, attributable to sewage pollution. |
| J. Brown - - | —— | Captain of yacht "Irene." | Do. do. |
| H. Eagle - - | —— | Captain of yacht "Little Emily." | Do. do. |
| A. French - - | —— | Captain of yacht "Venilia." | Do. do. |
| John Cornish - - | —— | Captain of yacht "Lolah," 20 tons. | Do. do. |
| Wm. Spooner - | —— | Captain of yacht "Challenge," 20 tons. | Do. do. |
| Adolphus Rand - | —— | Captain of yacht "Maritana," 20 tons. | Do. do. |
| Albert Rouse - - | —— | Captain of yacht "Primrose," | Do. do. |
| Thomas Barnard - | —— | Captain of yacht "Wenonah," 36 tons. | Do. do. |
| James Barnard - | —— | S.S. "Reseda," 25 tons. | Do. do. |
| H. Cook - - | —— | S.S. "Kitiwake," 20 tons. | Do. do. |
| F. Prizeman - - | —— | S.S. "Mascota," 14 tons. | Do. do. |

App. C.C.

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| | | General Witnesses. | |
| Robert Stone - - | 40, Pier Road, Erith | Barge owner - | This witness can speak as to the state of the river both before and since the outfalls, how it has become polluted by the sewage, and is so foul now that it quickly spoils the paint on the barges, and makes the ropes and anchor chains smell horribly, that the sewage settles on the banks and the bottom of the river in large quantities, and is forming in Erith Bight and other places banks of corruption. |
| Samuel Chittenden - | 53, Pier Road, Erith | Gentleman - - | This witness confirms generally the above statement. |
| Jonas Watts - - | Metropolitan Police, Erith Section, R. Division. | Coroner's Office - | Do. do. |
| Walter Ponting - | Do. | Do. - | Do. do. |
| Thos. W. Spencer - | 1, Yew Tree Terrace, Erith. | Master Mariner - | Do. do. |
| Wm. Jas. Young - | Cambridge Hotel, Woolwich. | Retired Master of London Steamboat Company. | Do. do. |
| John Pain - - | East Greenwich - | Bargeman - - | Do. do. |
| Robert Andrew Gibbons. | Of firm of Robins & Co., Northfleet. | Cement Manufacturer. | Do. do. |
| | | Captains of Barges. | |
| W. Richd. Stratfield | 5, Northfleet Creek, Kent. | Captain of barge "Ann Corsan." | Says:—Knew river before outfalls were erected. Then water and mud both pure; now it is poisoned, and river is silting up everywhere with a filthy deposit from the sewage outfalls, which settles on the bottom of the river, and which smells horribly, especially on the chains and anchors. The smell from the river water and mud makes witness heavy and drowsy, and causes loss of appetite, and he says nuisance is steadily increasing. |
| Lewis White - | 7, Grange Road, Plaistow. | Captain of barge - | Can confirm generally above witness. |
| Henry Tyler - | 2, Church Terrace, Grays. | Do. - | Do. do. |
| Alfred Cattaway - | 53, High Street, Grays. | Do. - | Do. do. |
| William Stowers - | 3, Brunswick Road, Gravesend. | Do. - | Do. do. |
| John Peartree - | Argent Street, Grays | Do. - | Do. do. |
| Edward Nettle - | 14, Wood Street, Northfleet. | Do. - | Do. do. |
| Samuel Cudmore - | West Thurrock, Essex. | Mate - - | Do. do. |
| Samuel Pettifor - | 3, Stonebridge Hill, Northfleet. | Captain of barge - | Do. do. |
| William Sutton - | 28, College Road, Northfleet. | Mate - - | Do. do. |
| Charles Fisher - | 9, Station Road, Northfleet. | Captain of barge - | Do. do. |
| John Cossey - | 34, High Street, Northfleet. | Do. - | Do. do. |
| John Gray - - | The Hill, Northfleet. | Do. - | Confirms generally evidence of Stratfield. |
| James Pellatt - | Northfleet Creek - | Do. - | Do. do. |
| Henry Adams - | Argent Street, Grays | Do. - | Do. do. |
| Richard Edmeads - | 14, Stonebridge Road, Northfleet. | Storekeeper, lately captain. | Do. do. |
| W. Walker - - | Stonebridge Road, Northfleet. | Captain of barge - | Do. do. |
| George Copsey - | Northfleet Creek - | Do. - | Do. do. |
| John Mead - - | 2, Market Place, Grays, Essex. | Do. - | Do. do. |
| Joseph Savill - | Bath Street, Gravesend. | Do. - | Do. do. |
| Thomas Brown - | 33, Bath Street, Gravesend, aged 66. | Captain of barge "Swift." | Do. do. |
| Edwin Debney Harvey | 39, College Street, Northfleet, aged 25. | Captain of barge "Perseverance." | Do. do. |
| Henry Robinson - | Northfleet, aged 37 | Captain of barge "Alert." | Do. do. |
| Alfred Knight - | 3, Granby Road, Northfleet, aged 31. | Captain of barge - | Do. do. |

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| George Rough - | 164, West Street, Gravesend. | Captain of barge "Chase." | Confirms generally evidence of Stratfield. |
| Mark Coppen - | 64, West Street, Gravesend. | Captain "Brothers" | Do. do. |
| H. Blake - - | 4, Howard Square, Northfleet, aged 32. | Captain of barge "Industry." | Do. do. |
| A. Pilcher - - | 1, Granby Road, aged 33. | Captain of barge "Progress." | Do. do. |
| Chas. Webster - | 47, Granby Road, aged 26. | Captain of barge "Conservative." | Do. do. |
| W. T. Court - - | 11, Portland Road, Northfleet, aged 46. | Captain of barge "Lively." | Do. do. |
| T. Stevens - - | Granby Road, Northfleet, aged 40. | Captain of barge "Success." | Do. do. |
| G. Hunt - - | 47, Shepherd Street, aged 30. | Captain of barge "Energy." | Do. do. |
| H. W. Jervis - | 12, Portland Road, Northfleet, aged 22. | Captain of barge "Edward and Eliza." | Do. do. |
| W. Paul - - | 36, Portland Road, Northfleet, aged 31 | Captain of barge "Northfleet." | Do. do. |
| Charles Hutson - | 8, High Street, Northfleet, aged 27. | Captain of barge "Portland." | Do. do. |
| J. W. Jervis - | 30, Stonebridge Road, Northfleet, aged 30. | Captain of barge "Prompt." | Do. do. |
| W. Mitchell - - | 39, Portland Road, aged 33. | Captain of barge "Seagull." | Do. do. |
| H. Taylor - - | 28, The Shore, Northfleet, aged 38. | Captain of barge "Osprey." | Do. do. |
| J. Lingham - - | 36, Portland Road, aged 37. | Captain of barge "Silver Wedding." | Do. do. |
| C. Draper - - | 2, Gladish Cottages, aged 36. | Captain of barge "Breakwater." | Do. do. |
| H. Jerviss - - | 12, Portland Road, aged 54. | Captain of barge "Active." | Do. do. |
| Alfred John Robinson | 3, Howards Square, Northfleet, aged 21. | Captain of barge "Heron." | Do. do. |
| Frederick Webb - | 26, The Grove, Northfleet, aged 24. | Captain of barge "Enterprize." | Do. do. |
| Elias John Dyke - | West Street, Gravesend, aged 22. | Captain of barge "Rapid." | Do. do. |
| Henry Adams - | Grays, Essex - | —— | Do. do. |
| J. Sutton - - | 27, College Road, Northfleet. | —— | Do. do. |
| W. Walker - - | Stonebridge Hill, Northfleet. | —— | Do. do. |
| Jas. Sutton - - | 28, College Road, Northfleet. | —— | Do. do. |
| Arthur F. Everish - | 30, Bath Street, Gravesend. | —— | Do. do. |
| John M. Stevens - | 39, High Street, Northfleet. | —— | Do. do. |
| Edward Laming - | 3, Station Street, Northfleet. | —— | Do. do. |
| George Lodge - | 26, High Street, Northfleet, aged 38. | Captain of barge "R. A. Gibbons." | Confirms generally evidence of Stratfield, and speaks as to difference between mud of the Thames and that of the Medway. |
| William Tremaine - | 13, Station Road - | Captain of barge "William Paxton." | Do. do. do. |
| Charles Carter - | 31, Waldridge Street, East Greenwich, aged 56. | Barge owner and lighterman. | Confirms generally evidence of Stratfield. |
| John Piper - - | 2, Pleasant Place, Woodland Street, East Greenwich. | Waterman - | Do. do. |

FREE WATERMEN and RIVER PILOTS.

| | | | |
|---|---|---|---|
| J. Warner - - | East Greenwich, aged 55. | Trinity pilot - | Can confirm the evidence given by Thomas Parkinson before the Commission on the fourth sitting, page 27. |
| W. Young - - | East Greenwich, aged 44. | Do. - | Do. do. |
| G. Parkinson - | East Greenwich, aged 26. | Do. - | Do. do. |

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| Thos. Goddard | East Greenwich, aged 60. | Trinity pilot | Can confirm the evidence given by Thomas Parkinson before the Commission on the fourth sitting, page 27. |
| W. Pain | East Greenwich, aged 65. | Barge owner | Do. do. |
| W. Parkinson | Greenwich | Waterman | Do. do. |
| S. Nevill | Do. | Pilot | Do. do. |
| R. West | East Greenwich | Do. | Do. do. |
| Saml. Carter | 2, Alfred Place, Bennett Street, East Greenwich. | Waterman | Do. do. |
| J. T. Parkinson | East Greenwich, aged 30. | Trinity pilot | Do. do. |
| J. Parkinson | East Greenwich | Pilot | Do. do. |
| R. J. Parkinson | East Greenwich, aged 36. | Do. | Do. do. |
| J. Parsonson | East Greenwich, aged 61. | Trinity pilot | Do. do. |
| T. W. Gibson | 4, East Terrace, Gravesend. | Free waterman | Do. do. |
| S. T. Walter | 15, Town Quay, Gravesend. | Do. | Do. do. |
| T. M. Hughes | 20, New Street, Gravesend. | Do. | Confirms evidence of Thomas Parkinson. |
| Thos. Waller | Clifton Shades, Gravesend. | Do. | Do. do. |
| William Martin | Gravesend, aged 89 | Do. | Do. do. |
| Thos. Henderson | 1, West Side Place, Gravesend. | Do. | Do. do. |
| John Whitbread | No. 15, The Terrace, Gravesend. | Do. | Do. do. |
| H. E. Hughes | 20, New Street, Gravesend. | Do. | Do. do. |
| W. J. Savage | 17, Edwin Street, Gravesend. | Do. | Do. do. |
| John Reader | 4, Terrace Place, Gravesend. | Do. | Do. do. |
| Jas. Smith | Do. | Do. | Do. do. |
| John Edwards | 26, Thames Terrace, Gravesend. | Do. | Do. do. |
| Edward Ogle | 3, West Street, Gravesend. | Do. | Do. do. |
| Isaac Coy | 47, Cutmore Street, Gravesend. | Do. | Do. do. |
| John Stephens | Bath Street, Gravesend, aged 73. | Do. | Do. do. |
| G. W. Martin, junr. | 16, Kempthorne Street, Gravesend. | Do. | Do. do. |
| G. Raspison | 37, Bath Street, Gravesend. | Do. | Do. do. |
| Henry Corby, senr. | 1, Nelson Place, Gravesend, aged 78. | Do. | Do. do. |
| C. L. Allen | 102, Wellington Street, Gravesend. | Do. | Do. do. |
| J. J. Watkins | 11, Wilfred Street, Gravesend. | Do. | Do. do. |
| W. Lawrence | 49, Kempthorne Street, Gravesend. | Waterman | Do. do. |
| George Martin | Gravesend, aged 73 | Do. | Do. do. |
| A. G. Pattison | 1, West Street, Gravesend. | Do. | Do. do. |
| James Martin | Post Office, Gravesend. | Do. | Do. do. |
| Philip Collins | 21, Crooked Lane, Gravesend. | Do. | Do. do. |
| Aaron Mason | 1, Cornwall Terrace, Pelton Road, Greenwich, aged 72. | Do. | Do. do. |
| James Grest Everson | 2, Brewhouse Lane, Garden Stairs, aged 55. | Do. | Do. do. |
| George Harvey | 8, Lower Park Street, Greenwich, aged 58. | Do. | Do. do. |
| Peter Brown | East Greenwich, aged 72. | Do. | Do. do. |
| Charles Brown | Baker's Yard, Greenwich, aged 62. | Do. | Do. do. |

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| Christopher Mears - | 83, Thames Street, Greenwich, aged 71. | Waterman - | Confirms evidence of Thomas Parkinson. |
| James Cheeseman - | Old Charlton Pier, aged 72. | Do. - | Do. do. |
| George Cheeseman - | Old Charlton Pier, aged 35. | Do. - | Do. do. |
| Joseph Richbell - | 7, Horseferry Road, Greenwich, aged 61. | Do. - | Do. do. |
| Thomas Barnett - | 9, Church Street, Greenwich, aged 49. | Do. - | Do. do. |
| William Marchant - | Church Street, Greenwich. | Assistant Inspector of Nuisances and Explosives under Thames Conservancy. | Do. do. |
| John Young - | 20, The Gardens, South Woolwich, aged 73. | Free waterman and lighterman. | Do. do. |
| Thomas Cox - - | Nile Street, South Woolwich, aged 65. | Do. - | Do. do. |
| William Pennyall - | Silvertown, aged 72 | Shipkeeper to L.S.B. Co. | Do. do. |
| Wm. Edwd. Reed - | Crown and Cushion Hotel, South Woolwich. | Retired Trinity pilot | Do. do. |
| Henry Evans - | 4, Rodney Street, Woolwich, aged 63. | Under waterman, and sand and ballast dredger. | Do. do |
| William Clark - | 9, Slade Green, Erith, aged 58. | Waterman and lighterman. | Do. do. |
| James Evans - | 2, Rodney Street, Woolwich, aged 60. | Under waterman - | Do. do. |
| William Foster - | 8, Anchor Alley, Church Street, Woolwich, aged 50. | Waterman - | Do. do. |
| George King - | 8, Nelson Street, Woolwich, aged 54. | Do. - | Do. do. |
| Christopher Evans - | 4, Rodney Street, Woolwich, aged 36. | Do. - | Do. do. |
| Geo. Wm. Everson - | 3, Billingsgate Street, Greenwich, aged 49. | Free waterman - | Do. do. |
| John Tanner - | 1, Cokeman Street, Greenwich, aged 65. | Waterman - - | Do. do. |
| John William Livett | 5, Alexander Terrace, Bridge Street, Greenwich, aged 62. | Free waterman - | Do. do. |
| James Harvey - | Garden Stairs, Greenwich, aged 48. | Do. - | Do. do. |
| Arthur Groves Blackmore. | 8, Church Street, Greenwich. | Do. - | Do. do. |
| Joseph Starkey - | Lakes Cottages, Thames Street, Greenwich, aged 55. | Do. - | Do. do. |
| James Rd. Groves - | 4, Alfred Place, Bennett Street, East Greenwich, aged 66. | Do. - | Do. do. |
| Joseph Wm. Tracey | 7, Union Wharf, East Greenwich, aged 32. | Waterman and lighterman. | Do. do. |
| Charles Smith - | 24, Nile Street, South Woolwich, aged 56. | Do. - | Do. do. |
| Thomas Hooton Chappell. | 2, Nelson Street, South Woolwich, aged 54. | Do. - | Do. do. |
| H. Farthing - | 24, Petton Road, East Greenwich, aged 58. | Waterman - - | Do. do. |
| Thos. Carter - | 36, Bennett Street, East Greenwich, aged 58. | Do. - | Do. do. |

App. C.C.

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| John Richards - | 8, Union Wharf, East Greenwich, aged 50. | Waterman - | Confirms evidence of Thomas Parkinson. |
| Thos. Webber - | 4, Gales Row, Straitsmouth, Greenwich, aged 66. | Do. - | Do. do. |
| Alfd. Thos. Wright - | 11, Queen Street, East Greenwich, aged 57. | Free waterman - | Do. do. |
| Charles Carter - | 31, Waldridge Street, East Greenwich. | Do. - | Do. do. |
| John Piper - - | 2, Pleasant Place, Woodland Street, East Greenwich. | Do. - | Do. do. |
| George Cambden - | 6, Brunswick Street, Blackwall. | Do. - | Do. do. |
| Thomas Crout - | South Woolwich - | Do. - | Do. do. |
| Thomas Evans - | Do. - | Do. - | Do. do. |
| Benjamin Twin - | Old Charlton Pier - | Do. - | Do. do. |
| Francis Baggart - | Do. - | Do. - | Do. do. |
| William Webb - | Do. - | Do. - | Do. do. |
| Edward Irvine - | Do. - | Do. - | Do. do. |
| William Long - | 6, Lewis Place, Union Street, South Woolwich. | Do. - | Do. do. |
| Timothy William Facey. | 8, Thames Street, Greenwich. | Do. - | Do. do, |

FISHERMEN.

| | | | | |
|---|---|---|---|---|
| John Beichteller - | 97, West Street, Gravesend. | Fisherman, 60 years old. | | Says best fishing ground before the sewage outfalls was between Woolwich and Gravesend, especially off Erith, where fish were caught in great quantities. The sewage quickly poisoned the water, and has by degrees driven all the fish out of the river. The sewage outfalls have also so polluted the bottom of river that impossible to move a net along it now from the stinking sewage matter there. That before the outfalls opened the mud was a bright, clean, healthy mud, full of fishes food. That the evil is increasing every year, and generally witness can confirm Mr. Cobb's evidence given before Commission on the third day, page 25. |
| James Moore - | Melbourne Place, Gravesend. | Fisherman, aged 67 | | Can confirm above evidence. |
| Frederick Garmer - | 4, Chapel Lane, Gravesend. | Do. | do. 76 | Do. do. |
| William Brown - | 9, Passenger's Court, Gravesend. | Do. | do. 70 | Do. do. |
| Thomas Lash - | 13, Passenger's Court, Gravesend. | Do. | do. 67 | Do. do. |
| John More - - | 29, West Street, Gravesend. | Do. | do. 65 | Do. do. |
| Robert Plumb - | 17, Thames Terrace, Gravesend. | Do. | do. 57 | Do. do. |
| Robert Beichteller - | 93, Edwin Street, Gravesend. | Do. | do. 61 | Do. do. |
| Edward Sharress - | 20, Thames Terrace, Gravesend. | Do. | do. 54 | Do. do. |
| George Waller - | 21, Thames Terrace, Gravesend. | Do. | do. 44 | Do. do. |
| James Leech - | 33, West Street - | Do. | do. 60 | Do. do. |
| Edward Moore - | 33, West Street - | Do. | do. 57 | Do. do. |
| Joseph Jones - | 19, West Street - | Do. | do. 57 | Do. do. |
| John Webster - | 15, Thames Terrace | Do. | do. 55 | Do. do. |
| Joseph Webster - | 7, West Side Place | Do. | do. 38 | Can confirm evidence of Beichteller. |
| Elias Warner - | 1, Melbourne Place | Do. | do. 54 | Do. do. |
| Samuel Grant - | 1, Mermaid Court - | Do. | do. 37 | Do. do. |
| Arthur Box - - | 24, West Street - | Do. | do. 26 | Do. do. |
| Joseph Jones - | 7, Somerset Street - | Do. | do. 32 | Do. do. |
| John Jones - - | 19, West Street - | Do. | do. 28 | Do. do. |
| George Shuttlewood | 18, West Street - | Do. | do. 37 | Do. do. |
| Thomas Shuttlewood | 15, West Street - | Do. | do. 28 | Do. do. |
| George Taylor - | 8, Melbourne Place | Do. | do. 42 | Do. do. |
| Richard Box - - | 24, West Street - | Do. | do. 64 | Do. do. |
| John Daniel Webster | 6, Arthur Cottages | Do. | do. 29 | Do. do. |
| William Shuttlewood | 42, West Street - | Do. | do. 44 | Do. do. |
| William Webster - | 9, Kempthorne Street. | Do. | do. 48 | Do. do. |
| Robert Webster - | 50, Kempthorne Street. | Do. | do. 36 | Do. do. |
| Thomas Brown - | 5, Lutley's Alley - | Do. | do. 43 | Do. do. |

| Name. | Address. | Occupation. | Nature of Evidence. |
|---|---|---|---|
| Jacob Beichteller - | 7, Terrace Court - | Fisherman, aged 30 | Can confirm evidence of Beichteller. |
| Peter Plumb - | 17, Church Lane - | Do. do. 44 | Do. do. |
| Johores Bortt - | 4, Church Street - | Do. do. 30 | Do. do. |
| Robert West - | East Greenwich - | —— | Do. do. |
| John Gooch - - | 25, Marlborough Street, Greenwich. | —— | Do. do. |
| William Cobb - | 6, Crowley Wharf, East Greenwich. | —— | Do. do. |
| Richard Stratford - | 3, Little Bennett Street, East Greenwich. | —— | Do. do. |
| John Barnham - | 6, Bennett Street, East Greenwich. | —— | Do. do. |
| John Shaw - - | 4, Queen Street, Greenwich. | —— | Do. do. |
| Richard Fuller - | 2, Jubilee Place, East Street, Greenwich. | —— | Do. do. |
| Charles Vincent - | 4, Garden Stairs, West Greenwich. | —— | Do. do. |
| Robert Stroud - | 8, Lamb Lane, West Greenwich. | —— | Do. do. |
| George Franklin - | 6, Horseferry Road, Greenwich. | —— | Do. do. |
| William Franklin - | 1, Ward Wharf, Horseferry Road. | —— | Do. do. |
| Edward Cobb - - | 3, Coltman Street, West Greenwich. | —— | Do. do. |
| Joseph Cobb - - | 22, Gassallee Street, Blackwall. | —— | Do. do. |
| George Murphy - | 6, Gassallee Street, Blackwall. | —— | Do. do. |
| Thomas Cobb - | 22, Gassallee Street, Blackwall. | —— | Do. do. |
| Charles Todd - - | 6, Garden Stairs, Church Street, Greenwich. | —— | Do. do. |
| Arthur Thos. Hart - | 22, Marlborough Street, E. Greenwich. | —— | Do. do. |
| William Farnham - | 7, Garden Stairs, Church Street, West Greenwich. | —— | Do. do. |
| George Diett - - | 2, Billingsgate St., Greenwich. | —— | Do. do. |
| William Young - | 42, Marlborough Street, E. Greenwich. | —— | Do. do. |
| Henry Blake - - | 1, Union Wharf, East Greenwich. | —— | Do. do. |
| John Brill - - | Globe Lane, Woolwich. | —— | Do. do. |
| George Hoskins - | 48, West Street, Erith. | —— | Do. do. |
| Richard Armitage - | 10, Nile Street, Greenwich. | —— | Do. do. |
| William Sego - | 27, Cross Street, Erith. | —— | Do. do. |
| John Thorn - - | 59, Marlborough Street, E. Greenwich. | —— | Do. do. |
| Christopher Cobb - | 4, Union Wharf, East Greenwich. | —— | Do. do. |
| Adam Edward Cobb | 6, Crawley Wharf, East Greenwich. | —— | Do. do. |

SUMMARY.

| | | |
|---|---|---|
| By the General Committee - - - - - - - - - | | 49 |
| By the Erith Local Board, &c.: | | |
| Yacht owners - - - - - - - - | 24 | |
| General - - - - - - - - - | 8 | |
| Captains of Barges - - - - - - - | 55 | |
| Free Watermen and Pilots - - - - - - - | 85 | |
| Fishermen - - - - - - - - | 61 | |
| | —— | 233 |
| In all - - - - | | 282 |

ROYAL COMMISSION ON METROPOLITAN SEWAGE DISCHARGE

GENERAL MAP OF

# THE MAIN DRAINAGE SYSTEM OF THE METROPOLIS.

See Evidence of
Sir Joseph Bazalgette, Q 16.

NORTHERN HIGH LEVEL SEWER

MIDDLE LEVEL SEWER

SOUTHERN HIGH LEVEL SEWER

NORTHERN OUTFALL SEWER

SOUTHERN OUTFALL SEWER

PIMLICO BRANCH SEWER

FULHAM BRANCH SEWER

EFFRA BRANCH

FALCON BROOK SEWER

RAVENSBOURNE AND SOUTH METROPOLITAN SEWER

RIVER RODING

RIVER LEA

FLEET SEWER

HIGHBURY SEWER

HOLLOWAY SEWER

STOKE NEWINGTON SEWER

HACKNEY SEWER

WICK LANE SEWER

LOWER WESTMINSTER PUMPING STATION

BARKING CREEK RESERVOIR

CROSSNESS RESERVOIR AND PUMPING STATION

DEPTFORD PUMPING STATION

A. Effra Pumping Station } for relief of Sewers in time of
B. Falcon Dº Dº } Storms and not generally in use

*The Blue lines show the Main Ordinary Sewers.*

*The Red lines show the Intercepting Sewers.*

*The small Blue circles show the Storm Overflows.*

DANGERFIELD, LITH 22 BEDFORD ST COVENT GARDEN

HACKNEY
STRATFORD
VICTORIA PARK
OLD FORD
WEST HAM
HOXTON
BOW
PLAISTOW
WEST HAM ABBEY MARSH
BROMLEY
STEPNEY
LIMEHOUSE
PLAISTOW MARSH
CANNING TOWN
BERMONDSEY
ROTHERHITHE
ISLE OF DOGS
GREENWICH MARSHES
CREENWICH MARSHES
EAST GREENWICH
DEPTFORD
GREENWICH
CHARLTON
NEW CROSS
PECKHAM
BLACKHEATH

(C.D.

ROYAL COMMISSION ON METROPOLITAN SEWAGE DISCHARGE

*Sketch Map shewing various points of outfall for the Metropolitan Sewage proposed at different times.*

BARKING

BARKING LEVEL

F

B.H.

A

ACTUAL

B

B*

WOOLWICH

A

B

PLUMSTEAD MARSHES

ACTUAL

B*

ERITH BEACH

PLUMSTEAD

LESNESS HEATH

ERITH

EAST WICKHAM

SHOOTERS HILL

**REFERENCES.**

| Mark. | | | |
|---|---|---|---|
| **F.** | *Frank Forster* | *1850 and 51.* | |
| **B.H.** | *Bazalgette and Haywood* | *1854.* | |
| **A.** | *Metropolitan Board of Works.* | *June* | *1856.* |
| **B.** | *D°* | *D°* | *Nov. 1856.* |
| **B*** | *D°* | *D°* | *Dec. 1856.* |

7099

DANGERFIELD. LITH 22 BEDFORD ST COVENT GARDEN

# ROYAL COMMISSION ON METROPOLITAN SEWAGE DISCHARGE.

## SKETCH MAP

*Shewing the points of Outfall proposed by the Government–*
*Referees = Messrs. Galton, Simpson & Blackwell.*
*July 1857.*

DANCER LITH. 22 BEDFORD ST COVENT GARDEN 3100

# INDEX TO THE DIGEST.


| Name of Witness. | Evidence. | | Digest Page. |
|---|---|---|---|
| | Day. | Page. | |
| Abel; Sir Frederick, C.B., F.R.S. | 42 | 622 | 861 |
| Adams; James | 8 | 110 | 783 |
| Armitage; Richard | 8 | 109 | 783 |
| Avent; Arthur | 37 | 554 | 851 |
| Bazalgette; Sir Joseph W., C.B. | 1, 32, 33 | 1,459 | 830 |
| Beadle; Charles | 1, 2 | 11 | 767 |
| Beale; Professor Lionel S., M.B., F.R.C.P., F.R.S. | 29 | 417 | 824 |
| Birch; R. W. Peregrine | 21, 22, 23 | 10, 337 | 808 |
| Bound; Walter | 31 | 449 | 829 |
| Bradley; William | 31 | 450 | 829 |
| Brill; William | 5 | 54 | 774 |
| Brown; Thomas | 8 | 111 | 784 |
| Brown; William | 8 | 114 | 785 |
| Browning; Benjamin, L.R.C.P. Lond. | 30 | 439 | 828 |
| Bruges; Charles Ernest | 29 | 424 | 825 |
| Burstal; Captain Edward, R.N. | 11, 12 | 166, 173 | 794 |
| Busby; Joseph R. | 2 | 16 | 767 |
| Carttar; E. Arundel | 6 | 75 | 777 |
| Chatterton; George | 33, 34 | 485 | 837 |
| Clarke; Henry | 5 | 67 | 776 |
| Clarke; James | 4 | 49 | 773 |
| Cobb, W. | 3 | 37 | 771 |
| Coleman; W. Warman | 34 | 501 | 840 |
| Collingridge; William, M.D. | 10, 12, 29 | 144, 180, 429. | 790 |
| Corfield; Professor W. H., F.R.C.P. | 29, 30 | 427 | 826 |
| Corner; F. Mead, M.R.C.S., L.S.A. | 38 | 563 | 853 |
| Custance; George | 31 | 451 | 830 |
| Dibdin; William Joseph, F.C.S. | 40, 41 | 591, 598 | 856 |
| Dickson; Walter, R.N. | 40 | 589 | 855 |
| Dixon; John, M.D., &c. | 38 | 557 | 851 |
| Doggett; Edgar | 38 | 562 | 852 |
| Dupré; August, Ph.D., F.R.S. | 41, 42 | 610 | 859 |
| Easton; Edward | 39, 40 | 579 | 853 |
| Edmunds; Augustus Robert | 7 | 95 | 781 |
| Egerton; William | 3, 8 | 30, 101 | 769 |
| Evans; Henry | 8 | 114 | 785 |
| Evans; William | 8 | 107 | 782 |
| Farthing; James William | 4 | 47 | 772 |
| Faulkner; Charles | 5 | 64 | 776 |
| Fitzgerald; Captain James, R.N. | 10 | 134 | 789 |
| Frankland; Professor Edward, F.R.S. | 26, 27, 28 | 378 | 817 |
| Fuller; George Frederick | 7 | 88 | 780 |
| Gatward; William | 6 | 68 | 776 |
| Gilham; Sergeant Charles | 6 | 79 | 778 |
| Gillett; Captain Arthur | 2 | 25 | 769 |
| Griffith; Surgeon-Major C. W. | 38 | 558 | 852 |
| Groves; John | 37 | 548 | 850 |
| Grundtvig; Conrad | 37 | 552 | 851 |

| Name of Witness. | Evidence. Day. | Evidence. Page. | Digest Page. |
|---|---|---|---|
| Harling, William | 5 | 66 | 776 |
| Hathaway; Joseph | 4 | 45 | 772 |
| Heaton; C. William, F.C.S. | 28, 29 | 406 | 822 |
| Hicks; William | 31 | 448 | 829 |
| Hind; Michael | 3 | 34 | 770 |
| Hoskins; William | 5 | 62 | 775 |
| Hughes; Edwin | 12 | 179 | 795 |
| Huntingford; Captain T. | 13 | 202 | 797 |
| Hussey; Captain James | 7 | 85 | 779 |
| James; Captain C. H. | 10 | 141 | 790 |
| Jessett; Frederic Bowreman | 8 | 107 | 783 |
| Jones; Henry | 13 | 201 | 796 |
| Lamerton; George | 10 | 156 | 792 |
| Latham; Baldwin | 15, 16, 17, 18, 19, 29 | 205, 425 | 797 |
| Law; Henry | 35, 36, 39, 41 | 506, 556, 566, 597 | 841 |
| Lee; John Godfrey | 5 | 61 | 775 |
| Lett; F., M.R.C.S. | 34 | 503 | 840 |
| Lewis; William Henry | 9 | 122 | 786 |
| Long; Thomas | 10 | 154 | 792 |
| Lynch; Captain G. Benjamin | 6 | 80 | 778 |
| McAllister; Rev. John | 9 | 116 | 785 |
| McKee; William Henry Joseph | 5 | 60 | 775 |
| Mansergh; James | 20, 21 | 281, 308 | 805 |
| Marsden; Captain Richard | 9 | 131 | 788 |
| Marshall; Thomas | 7 | 98 | 782 |
| Martin; Edwin | 13 | 203 | 797 |
| Martin; George | 8 | 113 | 784 |
| Mason; George Robert | 12 | 187 | 795 |
| Mason; Hugh Herbert, M.R.C.S. | 44 | 649 | 866 |
| Mason; James More | 12 | 185 | 795 |
| Mastin; George | 6 | 77 | 778 |
| Maxwell; Theodore, M.D. | 34 | 499 | 839 |
| Miller; Captain William | 38 | 560 | 852 |
| More; Charles James | 21 | 305 | 807 |
| Morrel; Captain Arthur, R.N. | 2 | 21 | 768 |
| Naylor; Richard John | 8 | 100 | 782 |
| Odling; Professor William, F.R.S. | 43 | 632 | 863 |
| Parkinson; Thomas | 4 | 51 | 773 |
| Passfield; Henry | 9 | 121 | 786 |
| Petrie; James Edward | 37 | 553 | 851 |
| Phillips; John | 11 | 162 | 793 |
| Plumb; Robert | 8 | 112 | 784 |
| Roberts; George | 6 | 71 | 777 |
| Rowarth; Alfred | 34 | 504 | 841 |
| Rozier; James William | 6 | 84 | 779 |
| Sandford; William | 2 | 18 | 768 |
| Saunders; George | 7 | 97 | 781 |
| Savery; Edwin | 4 | 41 | 771 |
| Shand; Edgar | 13 | 200 | 796 |

| Name of Witness. | Evidence. | | Digest Page. |
|---|---|---|---|
| | Day. | Page. | |
| Shepherd; Captain Walter | 7 | 94 | 781 |
| Short; Frank Job | 29 | 424 | 826 |
| Showell; George Robert | 9 | 133 | 788 |
| Showell; James Henry | 6 | 82 | 779 |
| Showell; John William | 8 | 105 | 782 |
| Sibley; Thomas Harry | 5 | 58 | 775 |
| Sorby; H. C., F.R.S. | 43, 44 | 639 | 864 |
| Spadaccini; Henry | 9 | 128 | 787 |
| Symons; G. J., F.R.S. | 13 | 188 | 795 |
| Tall; John | 8 | 114 | 785 |
| Tatham; Robert Gordon, M.R.C.S. | 40 | 587 | 855 |
| Thorne; John | 4 | 50 | 773 |
| Tidy; C. Meymott, M.A., M.B. | 23, 24, 25, 26, 28, 29, 42 | 339, 401, 417, 622 | 812 |
| Tripe; John William, M.R.C.P. Edin. | 37 | 537 | 848 |
| Turnidge; William | 11 | 157 | 792 |
| Tuson; Professor R. V. | 29 | 416 | 824 |
| Unwin; Professor W. C. | 22, 23 | 320 | 809 |
| Visser; Captain Jan | 9 | 127 | 787 |
| Voelcker; Augustus, F.R.S. | 42, 43 | 628 | 863 |
| Walter; Captain Frederick, R.N. | 2 | 24 | 768 |
| Way; Mr. John T., F.C.S. | 28, 30 | 401, 444 | 821 |
| Webb; Captain Henry | 13 | 202 | 797 |
| Whitaker; William, B.A., F.G.S. | 13 | 198 | 796 |
| Whitehorn; Captain Joseph R. | 7 | 92 | 780 |
| Williams; Captain Michael | 7 | 90 | 780 |
| Wise; Andrew | 38 | 555 | 851 |
| Wood; Charles | 31 | 450 | 829 |
| Young; George (Fisherman) | 5 | 56 | 774 |
| Young; George (Master of steamer) | 11 | 158 | 792 |

# DIGEST.

MR. CHARLES BEADLE, Member of the Firm of Beadle Bros. of Erith, and Commissioner for the purpose of maintaining the river wall.

POPULAR EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—Has known the river about 35 years, and has spent a great deal of his time on it, 225, 229, 250, 373, 309. When first he knew it, the water was clear and wholesome, 227, 228. People used to bathe at Erith, 233–4, but do not do so now, 419–22. Since the outfalls were made the river has been growing gradually more dirty and objectionable. At first the river was not charged with sewage, 234–5, 240, 378–9. Coming up from the Nore, the water first gets thick in the Lower Hope, and gets worse until the outfalls are reached. It improves as you get to Greenwich, and is tolerably clear at London Bridge, 253.

OFFENSIVE ODOURS.—In hot weather there is a very disagreeable smell which has got much worse within the last few years, 241–3. It is worst between Blackwall and Greenhithe, 254, and is more noticeable from half ebb to half flood tide, 257, 345–6. The water becomes black when the sewage is discharged into it, and in hot weather gas bubbles may be seen rising near the shore which emit a disagreeable odour, 255–9, 401–2. The mud of the river, which formerly was dark clay, is now black, and is so offensive that his workmen, of whom he employs between 200 and 300, 367, object to work on his vessels at low water, and make constant complaints of the smell, 260–7, 411. Has experienced it himself, and in hot weather it produces headache and nausea. It is decidedly a sewage smell, 301–6. There are no worms to be found in the mud now, 266–7. When the wind is blowing from the north, a great nuisance is caused by the smells from the different works and factories on the north side of the river. They are of a most offensive character, but are easily distinguishable from the smells from the river. Has detected smells from the factories at his house, which is three miles from the river, but never the sewage or mud, 348–63, 404–8, 418. The water gives off a disagreeable smell, which can be detected when on the river, 342–4.

POPULAR EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—Sewage matter has accumulated on the south side of Erith Bay during the last 20 years to a height of from 10 to 12 feet, but not on the north shore. It has increased more rapidly during the last 10 years, and is exposed at low water 150 feet further than formerly, 280–82, 311, 325–31. A buoy which floated at this place in 8 or 10 feet of water is now out of water at low tide, 283. The sun causes the exposed deposits to decompose and give off a gas, which is what he suffers from most, 288–90. The deposit is diluted sewage, 403. The stone causeway at Erith has been lengthened several times within the last 20 years to an extent of 100 feet on account of a deposit of black slimy mud around and over it. Now a floating causeway has been placed there, 291–5, 307–8. Has been obliged to keep a gang of men to flush the foreshore in order to keep it clear of deposit for the last two years. One man was sufficient for this purpose formerly, 425–32. The character of the mud has completely altered, and he has brought samples with him for analysis, 332–4, 434–5.

INJURY TO FISH.—When first he knew the river, the water was clear and wholesome, and twenty years ago fish could live in it, 227, 228. Has caught fish at Erith as recently as 10 years ago, 231–2, 238. It was a good place for fish, 239. Now all the fish are driven down as far as Sea Reach from Blackwall, and year by year go farther away, 245–52.

SET OF THE TIDE.—An empty dummy barge would drift with the tide from Crossness outfall to about Gravesend Reach, according to the strength of the tide. It would drift up further than the point it started from, 274–9. In Erith Bay the tide causes a back-water round the point, making an eddy strong enough to turn a boat's head up the river, 285–7. The

MR. CHARLES BEADLE—*continued.*

SET OF THE TIDE—*continued.*

tide goes from point to point, and does not sweep round the points more since dredging operations were commenced to remove the shoals, 313–20. There was always slack water at Erith Bight, 322. The low-water mark has advanced 150 feet further towards the middle of the river, 296–300, 307. The removal of the tongue at Coldharbour Point has not influenced the set of the tide above it, nor has it altered in the eastern part of Erith Reach, 323–4, 381–92. Vessels going up or down at this part keep well out in the stream, and go from one point to the other, 381–98.

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS.—Believes Erith has a lower death rate and is more free from zymotic diseases than most places, but the smells from the river and deposits affect the health of his workmen, and there has been more sickness amongst them during the last three years than before, 369–74, 376, 411.

MR. JOHN ROBERT BUSBY, Trinity House River Pilot, 59, Parrock Street, Gravesend.

POPULAR EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—Has been on the river for 40 years, and a pilot for 21 years. When first he knew the river, the water was clear, and very clean. It was always used for drinking and cooking purposes on board ship, both by passengers and crew, 436–42, 484–86. It began to get foul in 1855, and got worse each succeeding year, owing to the number of outlets from Jenningtree Point to Blackwall, 443. It is not so foul in wet summers, 444–5. In 1858–9 the water from Woolwich to Westminster was in a dreadful condition, 476–9, 513–15. In Long Reach the water is better, 447–9.

OFFENSIVE ODOURS.—From Erith to Woolwich the water is in a most offensive state, and when a ship is being towed up or down the smell is unbearable. The decks cannot be washed down with the water, as it is filthy and black as ink. Considers the river between these points to be most obnoxious, and it is a huge cesspool, 446. It is worst on a summer morning early, after dry weather, at neap tide. Has had to keep his handkerchief to his nose for an hour at a time, 470–71, 517, 523–4.

POPULAR EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—At Erith has noticed slush (which has come out of the sewer), deposited on the shore nearly ankle deep, 453–9. It has increased during the last 10 years on both sides of the river, viz.:—at Erith and Rainham Bight, 507–8, 525–7. The sediment is deposited on the bed of the river, but the dirty water comes back. Has seen a circle of black matter at high tide extending a mile from the outfall, 466–7.

SET OF THE TIDE.—The tide sweeps from bight to bight, 460. Before the dredging was begun, there was scarcely six feet of water at Cold Harbour and Rand's Hill, and has seen smacks run aground there. Does not think that the set of the tide was affected by the removal of the point, but it may run faster, 489–503. There is more water now, owing to the dredging, and vessels can go over the place where the shoals were, 504, 510–12, 522. The water is slack in the middle, and slacker on the north shore than on the south, 528–30. It is not slacker than it used to be, 531. Sewage discharged just after high water at Crossness would drift down to Gravesend with a spring tide, but would not be so obnoxious there as at Barking or Crossness, as the water has become more mixed with it. On a neap tide the drift would go as far as Greenhithe. It would go up as far as Greenwich, 461–6.

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS.—Attributes his own good health and appearance to steady habits, 482–3.

INJURY TO FISH.—Fish used to be caught between Barking and Erith 30 years ago, but is unable to say when they ceased to be caught at Erith, 472–5.

## Mr. WILLIAM SANDFORD, Shipowner, Tudor Lodge, Gravesend.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has known the river for 45 years, 28 years of which he was a Trinity Pilot, 534–6. Before the outfalls were opened, the river between Jenningtree Point and Blackwall was in a very foul state. It extended even to London Bridge, 540–4. From Jenningtree Point to Gravesend the water was not affected by sewage, 545. After the opening of the outfalls in 1864 the river for four or five years was fairly clear between Crossness and Gravesend. Since then it has gradually got bad, and now is in as foul a state as it was originally, 546–8. It is worst on neap tides at low water, for tugs and steamers stir it up, and make the water quite black. After heavy rains it is not so bad, 549–52. Recommends that the sewage be carried to the east shore of the Lower Hope below Gravesend, 647a.

Offensive Odours.—There are a great number of offensive smells on the river between Erith and Crossness, but in particular between Jenningtree Point and Crossness. Has noticed the smell from the factories which are higher up the river. The smells are noticeable always on the last of the ebb when navigating the river, 630–47.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Has noticed the accumulation of mud on the banks at Crossness. Formerly there was anchorage in 14 feet of water at Tripcock Point, and now you cannot approach it. At low water in other places there is not more than eight or nine feet of water where there used to be from 14 feet to 15 feet, 553. The deposit has been much greater during the last 10 years, 554. From Jenningtree Point to Erith the deposit has increased rapidly, 555–61. It is of a very offensive nature, 612–17.

Set of the Tide.—The ebb tide sets from Jenningtree Point (down Erith Reach) over to Cold Harbour Point. Except on the first flood, there is little strength in the tide between Church Hole and Erith, 562–70. A vessel drifting down would not go into Erith Bay on account of the slack water, 571–6. Has proved by an experiment that while the last of the tide is running down there is an under-current running up which he believes to be the young flood. It is perceptible one foot from the bottom to about six or seven feet from the bottom, 577–84. This under-current stirs up the deposits from the outlet at Crossness, 585–8. Sewage matter discharged at high water on a spring tide would not go below Purfleet, or at all events not below Greenhithe, because the body of a man drowned at Crossness is never picked up below Purfleet, 590. On a neap tide it perhaps would reach Erith, 591–2, 626–9.

Effect upon Health in the Neighbourhood of the Main Outfalls.—The smells arising from the river have not affected his health, though he has experienced a choking sensation, and a desire for fresh air when passing through this bad part of the river, 593–4, and would watch the time to avoid the smells, 595.

Injury to Fish.—Remembers fish in the river between Woolwich and Gravesend, though none have been caught for 12 or 14 years, 596, 602, 603. Whitebait was caught at Blackwall, and salmon and sturgeon below Woolwich, 604–7. Fish brought up the river in wells from Iceland would live at Gravesend, but now they would die if kept there, on account of the polluted state of the water, 596–601, 608–10, 618–21. Last summer a salmon was caught between the Nore and Gravesend in a net, 622–5.

## Captain ARTHUR MORREL, R.N.

### Training Ship "Cornwall."

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been in command of the "Cornwall" for nine years. She is lying at Purfleet, 648-51. Has known the Thames for over 20 years, and the water was used for drinking purposes when he first became acquainted with the river, 652–6. Of late years the river has become very impure from matter discharged into it, 659–61. Used to wash the ships' decks with river water, and the boys bathed in it; but has discontinued the practice for several years on account of the sickening smell which it emitted, and now uses fresh water, obtained from the Grays Waterworks for this purpose, 662–70. Used to bathe in the river over 20 years ago at Erith, 657-8.

## Captain ARTHUR MORREL—*continued.*

Offensive Odours.—The smell from the water has been getting gradually worse every year, 686.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Owing to his duties on board the "Cornwall," he has not had much opportunity of noticing the deposits of mud on the river banks, 687.

Effect upon Health in the Neighbourhood of the Main Outfalls.—There are on an average from 200 to 250 boys on the "Cornwall," 674. In 1875–76 a severe epidemic of typhoid fever broke out, and in consequence he discontinued to use the Thames water, 671–2. Since doing so, the percentage of illness has been less, 673–5. Since leaving off the water there have been no epidemics of typhoid, though there have been isolated cases, 676–84. Attributes a feeling of sickness which he experiences in the morning to the smells from the water, 685. There was an official inquiry into the health of the boys, especially with reference to the prevalence of enteric fever amongst them in 1878, 688–93. Denies the statement made by the medical officer in his report, that there is great freedom from serious sickness, and that minor ailments are rarely troublesome, 695. Extracts read from the report of Mr. Netten Radcliffe with reference to the outbreak of fever, the discharge of sewage from the outfalls, its distribution, &c., 701–7. Denies that fever or illness can be brought from the shore, as all the boys when they arrive on board are in good health, and are certified by the surgeon of the gaol from whence they come to be so, 708–10, 715. No serious illness has occurred to any boy immediately on arrival. He would have been some months on board at least, 710, 715–17. Has not noticed much smell arising from gases emitted from the mud when the ship's keel has touched the mud at low water; indeed, he believes the bed of the river under the "Cornwall" to be nearly free from deposits, 713–14. The cause of the outbreak of fever is not really known, nor could it ever be clearly proved, 723–4. The report of Dr. H. Leach, medical officer of the Port of London, dated 12th November 1875, referred to by Mr. Netten Radcliffe (Qq. 702 and 718), on the typhoid epidemic on the "Cornwall," was put in and read, 861–3. Extracts from a report to the Local Government Board by Mr. W. H. Power, dated 15th March 1880, on the outbreak of typhoid in 1878, were read, 864–76. From that report it appears that the cause of the outbreak was suspected to be due to the presence of trichina in the pork eaten by the boys, 877–9. Application was made to exhume the body of the boy who died, and on making a microscopical investigation of the abdominal muscles a living *trichina* was discovered, while traces were found of the presence of others which were dead. Dr. Power holds that this proves most conclusively that the boy died from trichinosis and not from typhoid fever, as stated at the post-mortem examination, 879–82. Professor Cobbold did not believe the animal or specimen to be the real trichina, 883–4.

## Captain FREDERICK WALTER, R.N.

### Training Ship "Arethusa."

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is in command of the "Arethusa" stationed off Greenhithe, 725–727. Has been in command for eight years, and did not know the river before, 729. It has been getting worse each year, especially during the last four years, 730–732. In hot weather and at low tide it is worst, and has noticed smells arising from it, 746–7. The boys bathe at the top of high water only, 754–5.

Offensive Odours.—Smells are noticed principally at low water, and believes the worst smells arise from the mud, 756, 758–60. They are more noticeable when the water is stationary than if it is running, 761–2. In hot weather the smells are very bad, and the mud on the banks smells both at high and low tide, 785–6. The Canton River and the mud in it are both offensive 788–91.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Can see the mud on the banks from the ship, though he is unable to say whether the deposit has increased of late years, 748–9. Is about eighty yards from the low-water edge, 752, and about 150 yards of mud are exposed, 757. The colour of the mud has not altered during the last eight years, 750–1. Has had no experience of Thames mud at any other part of the river, 787.

## Captain FREDERICK WALTER, R.N.—*continued.*

Effect upon Health in the Neighbourhood of the Main Outfalls.—There was an attack of typhoid fever on the ship in 1879–80, 738, 777. It lasted nine months, 778–9. An enquiry was made into the origin of the outbreak, but never discovered the cause, 781–2. The decks were washed with Thames water prior to the outbreak of fever, but on discovering that it smelt very badly if it remained on the deck, the practice was discontinued. The water was very dirty and impure. It is still used for washing the upper deck, 739–45. The general health of the boys is very good; since the fever there has been less serious illness than before, and there has been no typhoid since discontinuing the use of Thames water, 765, 794–7. Two boys died in 1881, one of consumption, the other from an affection of the lungs, 767, 770–1. It was certainly not due to the water or the smell, 772. The year before there were two deaths, 773. There are 313 boys on board, and their age on entering varies from 13 years to 17 years, the average age is 15 years, 776, 768–9.

Injury to Fish.—Until four years ago boats used to come up to Greenhithe to fish for shrimps and dabs. There have been none since, 733–6.

## Captain ARTHUR GILLETT, R.N.

Training Ship "Warspite."

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been in command of the "Warspite," which is stationed off Woolwich, nearly five years, 798–800. The state of the river has not varied (though just now it is very clear), 801–3. Generally in July it is very bad, the water becomes slate-coloured, and great masses of black mud come up from the bottom which spread over the surface, 804–6, 860. In winter the river water is used for washing the upper deck and kitchen utensils, but never in summer, because of its bad state, 819–22. Samples of water taken from mid-stream at low ebb, opposite the ship, on being analysed, were reported to be "slightly diluted sewage," 814–17, 857.

Offensive Odours.—The smell from the river in summer is dreadful, and the ports have to be closed; the deck under the hammocks being kept wet with disinfectants for about a month, 806–10. It is equally bad at all times of the tide, 811. If anything, last year was the worst, 812. Has smelt the mud 30 feet above the level of the water, 846. The river mud at Woolwich does not smell, 842–5. There is no mud bank near the ship: it is washed away, 847–8.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—On one of the mooring chains parting last year it was discovered that it was covered with sewage, 813, 837, 858–9. When the river becomes slate-coloured the oars and blades turn black, 804, 825. The floating particles of sewage sink and are deposited at the bottom of the river. The whole bed of the river, he believes, is nothing but sewage. When the temperature rises the gas explodes and great masses of black stuff come up and spread over the surface, 828–36. Is not aware that black matter accumulates at the bottom of ponds into which no sewage is discharged, 839–41. Steamers passing at low-water stir up the sewage, 830.

Set of the Tide.—Does not know the operation of the tide above and below the "Warspite," having only a general knowledge of tides, 813. Sewage discharged at high water would drift about fifteen miles on the ebb. It certainly comes up to Woolwich from Barking and Crossness, 826–8.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Every year there have been isolated cases of typhoid fever which can only be attributed to the state of the river, 818. There are 200 boys on board, and they are remarkably healthy. There is no sickness at present. The average age of entering is 15, 850–5.

## Mr. WILLIAM EGERTON, Belvidere.

Surveyor to the Erith Local Board, and Inspector of Nuisances.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has lived at Erith for 21 years and at Belvidere for 5½ years, and has known the river all that time, 895–900. Since the opening of the outfalls there has been a very great alteration in the river. The discharge from the sewers can be distinctly seen and traced down to Erith by the different colour. Below Erith he does not know the river, 912–5. There is a discharge from Price's oil factory into the "common sewer ditch" (which is really a marsh drain), and which flows into the river, 949–50, 983–9. The ammoniacal liquor from the gas-works is put on barges and taken up to London. There is no discharge from these works into the drain or river, 4295–7.

## Mr. WILLIAM EGERTON—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

Offensive Odours.—There is a very bad smell at times from the water, like that from a recently emptied cesspool, and especially when the wind is off the river. It is worst in warm weather, and at half ebb tide, 917–20. As inspector of nuisances has visited the factories on the south side of the river situated for the most part between Jenningtree Point and Erith. Offensive smells come from most of them, and he can distinguish the various smells. They are entirely different to the smells from the river, 921–948. The smells from the factories on the north side are also different to the river smells, 951–2. With a hot sun, and the wind off the water, the smell from the mud is nauseous and very unpleasant. The factory smells can be avoided, but you cannot avoid the river smell, 976–7. It arises from both the river and the mud, 1006–7. Of the two would prefer the smell from the factories, 1008–16. It has been worse during the last five or six years, 1033, and the smell can be noticed from Jenningtree Point (Johnson's works) to beyond Erith on the road to Crayford, 1035–6. With westerly winds it is not so noticeable, 1037–43, 1057–8. It varies according to the direction of the wind, and the state of the weather, 1059–62. In the spring of 1882 he received instructions to specially inspect, with Mr. Ogston, the factories on account of complaints being made by the inhabitants of Erith that the smell was a nuisance. The complaints were well founded, and alterations had to be made in the machinery, &c. Since then an inspector of factories has been appointed under the Alkali Act, and the nuisance is less, 1063–74, 1078–85.

Wishes to correct a statement about the position of Jenningtree Point (Q. 934). He thought it was higher up than it really was, 4156–7. Is of opinion that there is more nuisance caused by the smell from the accumulation due to the outfall than there is from the discharge of sewage at Erith, 4208. Has frequently been consulted as to steps to be taken with regard to nuisances arising from the smell or other causes from the factories at Erith, regarding which complaints have been made, 4213.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—There has been a considerable alteration in the low-water mark during the past twenty years. Two buoys for moorings put down in nine and fourteen feet of water at low water respectively are both now frequently aground. The water recedes some yards from the first buoy. They have never been moved, and vessels cannot swing at the buoy, 901–11. There has been an increased deposit of mud at Erith on the banks in this time, and the colour is much darker. There is much more of it also, 969–72, 974–5. Just above Church Hole between half ebb and half flood vessels swing round the reverse way to what they would in the stream, often fouling their anchors, 973. There are no sewers where the mud lies thickest. Where the largest sewer discharges there is less mud and filth. The deposit is thickest opposite the two ballast wharves, 4183–6.

Set of the Tide.—From Crossness, the sewage discharged at the top of the ebb tide would for the most part go down the centre of the stream to Erith. Below that point can give no opinion, 965–8. It is to be distinguished by the colour and the "streamage," or corks, &c., which go along each side of it, 1044–8. The discoloration extends over about one eighth part of the river, and the smell can be detected from the banks, 1044–56.

Effect upon Health in the Neighbourhood of the Main Outfalls.—The smells arising from the river, and living so close to it, affected the health of his wife to such an extent that he had to change his residence eight years ago, 978–82. His house is now 170 feet above high-water mark, 1075–6. The smells have not affected his health since he removed to higher

Mr. WILLIAM EGERTON—*continued.*

Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

ground, 1077. Erith is as healthy as the surrounding districts, and the death rate is below the average, 990–1, 995. The high land is much more healthy than near the river, and the only case of typhoid fever as reported in the latest return of the medical officer occurred on the high land, 996–1000.

Injury to Fish.—About 24 years ago there used to be fish in the river at Erith, and he recollects the Dutch eel boats coming up until nine years ago. They discontinued doing so, as the fish could not live in the water there, owing to its impure state. Some eels were picked up on the mud three years ago in a dying state, 953–64, 1001–5.

Petitions, Inquiries, and Reports on alleged Nuisances.—In consequence of a petition presented to the Local Board, steps were taken to inquire into the nuisances caused by the factories in 1880, and Mr. Ogston, a professor of chemistry, was employed by the Board. In 1881 he (witness) reported to the Board that a serious nuisance was caused by the offensive state of an open ditch at the back of Messrs. Price's works, which produced offensive smells. This ditch had an outlet into the Thames. Within the last two years has been called on to visit and report on several factories which have been complained of as nuisances, 4216–36. There is no other factory which discharges refuse into the Thames, 4236. About November 1881, presented a report to the Board, on the works of Messrs. Price, Messrs. Callendar, Messrs. Berger and Spence, and Messrs. Collins. From Messrs. Collins' works has found stagnant water and offensive matter flowing from the hides and material on the river wall into the river, 4246–54. The Erith Local Board prosecuted a firm for landing particularly offensive manure at a wharf in Erith, which was a nuisance to the inhabitants, at which prosecution he gave evidence. The cause of the nuisance was due to their letting the manure remain on the wharf longer than was necessary. Complaints had been made on previous occasions as to the smell, 4237–45.

Population of Erith.—There has been a great increase in the population of Erith during the past 17 years to the extent, he believes, of about one-third more, 4287–8.

Drainage of Erith.—There are 1883 rateable houses in Erith, 507 of which are drained into the Thames, and 1,376 drain into cess-pits. For the purpose of draining those 507 houses there is a public sewer with a 15-inch iron pipe at the outlet which runs into the Thames off the South-eastern Wharf. Another goes from the Bexley Road across the High Street into the Thames with a 12-inch pipe, opposite a beershop kept by a man called Wiggins; and there is a branch 9-inch pipe which comes down Cross Street and discharges close by the flour-mills, a little above the causeway, 4158–69. The main sewer pipe runs into the river about 80 yards, but does not extend to low-water mark, 4187–9, 4194–206. Does not know how many houses it drains, 4212. The houses which drain into this sewer are for the most part cottages and modern houses. Those which drain into cesspits are mostly old houses, 4283–6. There is a 6-inch outlet from the works of Messrs. Shuttleworth & Chapman, and these are all the sewers he knows of which discharge into the Thames, 4170–6. The cesspools are self-contained, and have no overflow, 4190–3. The contents are emptied by farmers and put on the land. Slops go into them, and if the pits are made in the gravel, they are to a certain extent porous, 4289–94. Assisted a Committee of the Board last year in investigating the question of the factory nuisances, but has not been so engaged this year, 4259–61. The new Act came into operation on the 1st of January, 4262. Has served notices on inhabitants to abate local nuisances, but is unable to remember the particulars, 4263–9. There are two manure works at Belvidere, but has not visited them this year, nor is he aware of any complaints being made respecting them this year. Mr. Ogston has not been called in to report on them, 4270–2. Notice was given to Messrs Price and Company last year, to abate the nuisance caused by a ditch, which has been cleared out, 4273–6. Since inspecting the factories and serving notices on the firms the smells from them have been very much better, 4277–80. Makes reports to the Board after visiting the factories from notes which he makes, but keeps no diary, 4298–300. The gulleys which take the surface water from the roads are attended to from time to time. It varies from a week to a month according to the state of the weather whether wet or fine, 4178–81.

Mr. WILLIAM EGERTON—*continued.*

Drainage of Erith—*continued.*

Proposed Drainage for Erith.—About four or five years ago, Mr. Edward Easton was called in to prepare a scheme for draining Erith, and he reported on the state of the drainage, 4209–11.

## Mr. MICHAEL HIND, Erith.

Auctioneer and Undertaker. Member of the Local Board of Erith.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is 54 years of age, and has lived at Erith all his life, 1088–9. There have been great alterations in the state of the river during the last twenty or thirty years, since the opening of the outfall, 1090–2. It was much purer, and there was not so much sediment. The sewage in the river increases every year, 1093–5. Remembers the river water being used for drinking purposes fourteen or fifteen years ago towards the Pool. The ships used to fill up their breakers in the Pool, and take it to sea. Off Erith it was used for culinary purposes, 1096–9. At high water off Erith the water would be (at that time) a little brackish, but not at low water, 1100–1. Has oftened bathed in the river, but would be sorry to do so now, 1143–5.

Offensive Odours.—Has noticed a very unpleasant smell coming from the river which resembles the smell of a cesspool recently opened, 1116–7. It has not been so bad this year, because the summer has not been so hot, and there has been also more rain, 1118–9. It is most noticeable in hot weather, and when the wind blows from the north to east, especially in foggy weather, 1120–1. The mud on the river banks has a very offensive smell, which is much worse than it used to be, 1147. The smell which comes from the factories is very different to the river smell, and people who have lived any length of time in the neighbourhood can detect the difference directly, 1147–9. The smells from the factories on the south side are not alike, and he can distinguish between them. They are all unpleasant, but none are so bad as the river smell, 1150–8. The north wind brings the smell of the factories on both sides of the river to Erith. Is not acquainted with the factories on the north side, and cannot distinguish the smells from each as he can on the south side, 1163–76. The works on the north side are not opposite to Erith, but are two miles or more further up the river, 1177–83. Directed an enquiry to be made into the complaints of smells from the factories within his jurisdiction a few months ago, 1184–90. If the Commissioners or the examining counsel would only go to Erith, they would be convinced of the reality of the smell from the river, 1204–5. It is more noticeable when the wind is light than when it blows hard, and in foggy rather than bright weather, 1206. The smell of the mud is totally changed since the outfalls were opened, and increases continually, 1213–15. Has not conferred with the Inspectors of Nuisances on the evidence they were going to give, nor agreed as to what they should say, 1160–61.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Lives exactly on the causeway, which has had to be lengthened more than 100 feet, and raised more than three feet, owing to the deposit of mud which entirely covered it, 1102–6. Its present length is over 400 feet, and before being lengthened there used to be 12 or 13 feet of water at the end, in which a large yacht drawing ten feet of water could swing, without grounding, within twenty feet of the causeway. Now that part is quite out of water and dry at low spring ebb, and there are thirty feet of dry bank at the end of the causeway, 1107–8. The deposit has been accumulating since the opening of the outfalls, and increasing gradually year by year, 1109–10. The causeway this morning at 8 a.m. was covered with black stinking mud. At the end there is at least ten or eleven feet perpendicular of solid mud, 1111–15. Remembers the accident to the steamer "Princess Alice," which happened at Tripcock Point, just above the northern outfall between North Woolwich and Halfway Reach, 1127, 1130–1. Of the twenty-nine bodies which he saw brought ashore at Erith, those which had been in the water three or four days were in a dirty filthy state. All their underclothing was

Mr. MICHAEL HIND—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

saturated with "perfect muck," and their clothing was in an exceedingly dirty state, which gave off an offensive smell, 1128–29, 1132–1136. Before the outfalls were opened, bodies drowned, and the clothing, were in a much cleaner state, 1137–42. There is a very great difference between the mud on the banks before the outfalls were opened and the present time, both in colour and quantity. Years ago the mud at the edge of the river was much lighter in colour and only ankle-deep. Now it would be up to your waist and most offensive in smell, 1145–7. Inshore in Erith bay there is a large amount of mud which has reduced the strength of the tide considerably. It causes an eddy also which extends from below Church Hole to below Easton and Anderson's Works, 1199–1203. The accumulation of mud is not in any way due to the causeway, because the mud is on both sides of it, but more on the side nearest to the outfall. It cannot be said to be a breakwater, as part of it is on piles, and there is a large amount of deposit three hundred yards from the causeway around the wharves and piers, with nothing to prevent it being washed away; and gangs of men are kept for the purpose of washing and flushing it into the stream, 1207–12.

Set of the Tide.—There is a very great change off Erith now as regards the current. It is further out in the stream than it used to be, and the ebb just after high water goes from angle to angle, 1191–5. There is not so much current now as there used to be, owing to the accumulation of mud, though it takes the same direction, 1196–8.

Injury to Fish.—A great many fish used to be caught off Erith before the outfall was opened, between Church Hole and Rainham Ferry, also in Aveling Bight near Purfleet. None have been caught there for eight or ten years, and the boats have gone down lower and lower, until now they have got to Lower Hope, 1122–6.

Mr. WILLIAM COBB, East Greenwich.

Fisherman.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is 75 years of age, has been engaged in fishing for 60 years, and is the oldest fisherman on the Thames, 1216–18. Has known ships take water out of the river at Deptford and Blackwall for drinking purposes, and has drank the water himself. It was clear beautiful water then, but he would not do so now, 1240. It stinks now, and is of different colours, according to the way the stream is running. As for the bottom, a pole would stand in it, and the pole when pulled up smells worse than any closet. (*Exhibits signs of disgust.*) 1240–4. The Dutch eel boats which used to go up the river on the neap tides are now obliged to pack the fish in boxes and send them quickly up to London from Holy Haven (seven miles below Gravesend) because they cannot take the fish through the sewage water. Has experienced this himself, as, if left in the well, the heads of the eels would swell, and they would be of no use. If an eel is put into sewage water, it kills it at once, 1269–73, 1275. Is obliged to take the boxes up from the river at Gravesend, and place them in the boat, and they cannot be put into the river again until the Pool is reached, 1274. Has not noticed any "scum" from the factories on the river of any consequence, 1333. The "skimmage" of the tide between high and low water, wherever it pitches, is known as "scum froth." It has an oily appearance, and does not kill the fish. Does not remember grumbling at any discharge from the factories, 1332–41, 1417. Has seen fish killed by the discharge of sewage from the outfalls in various reaches, 1342–9. Has seen the discharge of sewage many times. It continues from the ebb tide until the flood tide stopped it; that is from about two hours and a half after high water until about two hours before high water, or from half ebb to half flood. This happens every day, 1281–83, 1371–86. As much sewage flows out upon the flood as upon the ebb, and has seen it this year at both the outfalls, 1387–93. There are no worms in the mud now, which is quite different to what it used to be, 1416. A meeting of fishermen was held at the "Golden Anchor" about a week ago, at which the evidence to be given was discussed, and the men were asked to attend. Witness, as the oldest hand, was asked to collect evidence, 1353–69.

Mr. WILLIAM COBB—*continued.*

Offensive Odours.—The smell from the mud at the bottom of the river is very strong, and is worse than any closet, 1243–4. Could prove it if anyone present went down the river in his boat, 1262. Has noticed a smell from the factories, but not like the river, 1329–32.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Ever since the outfalls were opened the fishermen's nets, when taken out of the water, are corroded with all manner of filth, and they could not get them clean if they were to put them in now, 1236–8. The causeway at Erith has been lengthened several times on account of the accumulation of mud, and there is now at least 12 feet clear settlings of all kind of mud there, which is caused by the tide coming round the point, 1245–6. At Church Hole the bottom used to be hard gravel bottom, but now it is covered with a black filthy sort of mud, which increases every day, 1247–54. A fresh in the river would make a slight difference by washing a little of it into deep water, 1255–6. Thirty years ago the mud at Erith was the same as is now to be found in the Medway. It had a bright colour (whitey-brown), full of red worms, which were good for bait. There are no worms now at Erith, 1257–61, 1394–1400. The mud was sandy and sweet, with a hard gravelly bottom, 1401–12, 1416. "Saltings," which are used for repairing the banks, with the aid of planks and stones, have not caused a deposit of mud, 1295–8. Last winter he tried to regain an anchor which was lost in mid-stream near the sewer, but failed to recover it. Attributes its loss to the depth of the deposit at the bottom of the river in which the anchor buried itself, 1299–1306. The sweep line, when hauled in, was covered with deposit as thick in circumference as witness's arm, 1307–9.

Set of the Tide.—There is an under-current, both at the ebb and flood tides, but it is not so strong as at the surface. In the bays there are back waters or eddy tides under the lee of the points, but they do not interfere with the current of the tide, 1290–4. Sewage discharged at Crossness at high water on a spring tide would drift down to Gravesend. Has drifted as far in his boat without touching the shore. It would return on the flood to Erith. If discharged on the flood, it would go to Greenwich. If discharged four hours after high water, it would go as far as Purfleet and return to Woolwich, 1287–9. Has noticed it daily, because he has been towed up astern of steamships, 1284–6.

Injury to Fish.—Erith Reach was the principal and best fishing ground in the river up to 20 years ago, 1219–22. Has fished from Greenwich to Gravesend, and caught all kinds of fish. The largest quantity of fish ever caught was in Erith Bight, 1223–8. Within a week after the opening of the outfalls the fish were seen swimming on the top of the river, and the swell from the steamers drove them ashore, and they died. This has continued ever since, and no fish are to be caught now in the river above Gravesend. The men are driven down to the sea, 1229–34. Whitebait and eels were used as bait for hooks, which were laid on the bottom, but now the hooks and lines would become fouled with filth, 1235. Fourteen or fifteen boats used to fish at Erith, 1245. Shrimps can only be caught in the Lower Hope now. Two years ago they were to be caught at Gravesend. Eels were caught as high up as Woolwich, 1263–5. A month ago he tried fishing at Greenhithe, but caught nothing, and his lines are so stained that it will not come out, 1266–68, 1310–16. Never remembers such a thing happening before, 1317–9. Where there is a great accumulation of mud it is no use fishing for eels or flounders. The hooks and baits would be buried, 1320–3. Has caught more whitebait off Greenwich than any other place, but now has to go to Southend and Sheerness. Whitebait swim on the surface, or within a foot of it, 1324–8. The small amount of refuse coming from the factories has not affected the fish, 1417.

Mr. EDWARD SAVERY.

Examining Officer of Customs at Erith.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been at Erith nine years, and is on the river every day. In hot weather the river is very bad; but the last few years, owing to the wet season and cool weather, it has not been so bad as in former years, 1421. The sewage can be seen distinctly in the river. The water is hardly ever clear now except sometimes just after low water, 1423. Has known the river for 40 years, and can remember drinking the

## Mr. EDWARD SAVERY—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

water at Erith and Blackwall. It was then very clear. Vessels going to sea used to take their supply of water from the river about half-an-hour before the flood, as it was then freshest, 1424–5. Thinks none would be so unwise as to drink it now, 1426. There is a great perturbation in the water now apparently from air bubbles. It was formerly like spring water, 1427–8. Amongst sailors there is a common idea that water is not fit to drink, or rather not good, after you have gone to sea, until it has undergone one fermentation, 1429. The water at Purfleet would not be drinkable at low tide if there was no sewage now, on account of its being brackish, 1432–7.

Offensive Odours.—The smell from the river can be noticed on shore, but at times on the river it is unbearable, and if it lasted, would incapacitate the men from doing their duty, 1421. It is worst in Half-way Reach, where the sewage is quite black, 1422. At low water on a hot day the smell is dreadful, 1442–3, especially from half way down Erith Reach to the top of Halfway Reach, 1465–9. Has noticed the smell from the factories in the atmosphere, but not from the river. They get the smell from the factories in the houses at Erith, but seldom the sewage odour. Can distinguish between the different smells, 1470–3, 1509–10A.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—From Erith, and a little below Erith, up to the outfall, there is a large accumulation of black sewage along the banks, and he has lifted some with the blade of his scull. It appeared to be pure black sewage. This deposit is not found in Long Reach or at Greenhithe, Grays, or Purfleet. Why, he cannot say, but it extends from the outfalls to Erith Reach, 1430–1, 1474–9, 1511. There are eddies in Erith Bight, and vessels swing up two hours after ebb-tide as if it were flood-tide. It is due to the silting up of the river, 1438. Small vessels which used to anchor close in under Erith Bight to wait for the tide now have to anchor at least 50 yards further out in the stream, and steamboats which used to go without difficulty over a certain course now stir up the mud. The deposits on the shore are now 15 feet high, 1438–40. The deposit is not due to the breaking down of the river banks. It smells too much, 1441. In consequence of the accumulation of sewage, which some people say is the banks of the river, the causeway has had to be lengthened twice, in all about 90 feet. The sewage lies in heaps and piles, and is decidedly increasing. "It is black and smelling," 1444–46. The principal place for the deposit is Erith Bight, 1461–62, 1474. The mooring buoys off Erith are not now in such deep water as when they were put down, and vessels ground now when before they would float, 1463. Has pushed a scull between five and six feet into the mud, 1464. Has observed the accumulations increasing daily for four or five years in Erith Bight, 1480–2. Several thousand tons have been removed by dredging, and the shoal known as Erith Rands has been removed. The channel is consequently much improved, but a vessel grounded there not long ago, 1483–6. The channel, being deepened, takes the stream more over to the north side and causes an eddy on the south side to a certain extent, which *might* have the effect of accumulating mud (not sewage), 1487–91. Is able to distinguish between sewage mud and river mud from seeing the delivery of genuine mud at the cement works, 1492–5, 1506–8. Part of the sewage of Erith is discharged into the river by an open sewer. A great part of the Erith sewage, however, goes into cesspools, and not into the sewer, 1496–1505. Is of opinion that if the present system of discharging sewage into the river is continued it will silt up the river, 1512. The mud used for making cement is of a light colour, but in all his experience of deposits he never saw any deposit which looks and smells like that which is seen at Erith. With a long enough probe you could pierce it to the bottom, which is estimated at 15 feet, 1516–19.

Set of the Tide.—The sewage discharged into the river at the outfalls would become so mixed with water that it would not be perceptible below Northfleet Hope or Southend, 1451–5.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has had applications from the officers on board ships for medicines to check diarrhœa, which it was presumed was caused by the state of the water, 1460.

## Mr. EDWARD SAVERY—*continued.*

Injury to Fish.—Fish used to be caught until about six years ago about Erith and Halfway Reach. The eel-scoots had to leave Erith *before* the opening of the outfalls, which he attributes to the state of the river. The sewage which used to be such an annoyance at Westminster now causes the same annoyance at Erith. The fish are poisoned by the sewage now as then, 1447–9. The eel-boats, as well as other fishing boats, stop now at Thames Haven, 1450, 1456–9. The discharges from the factories do not kill the fish, because it is well known that fish are abundant in the Tyne, where there are more factories than on the banks of the Thames, and therefore the conclusion to be drawn is that the sewage and not the chemical works kills the fish, 1512–15.

## Mr. JOSEPH HATHAWAY, East Greenwich.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been on the river for 50 years as a fisherman, and in the Thames Police, 1520–3. Prior to 1865 the water in the river was in a beautiful state, and could be drunk in any reach, 1530–2. Has drunk it himself, and has seen ships outward bound taking it in at Deptford, 1533. When the water was clear the fishermen's nets lasted twice as long as they now last. The water in its present state rots the nets, and it is impossible to clean them; they smell so bad also "that you can hardly bear them in the boats," 1561.

Offensive Odours.—As inspector in the Thames Police, his district extended from Blackwall to Deptford Creek; and has smelt the river in consequence, 1566–8. The smell from the river does not reach his house, but on the river has detected it as far up as Blackwall Reach, and even in Greenwich Reach when the spring tides are "running heavy." When on the river in the police galley, "especially in the summer time, there used to "be such a faint, nasty, stinking smell that you could "hardly bear it, and it turned you sick" when the sewage was being discharged, 1589–1600. If the police saw offensive matter in the river, they had to summon the people, 1601–2.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—There is a large deposit of black stinking mud on the banks on both sides of the river. It extends on the south side from Crossness to Erith. The causeway is overflowing with five or six feet of this sewer stuff. It goes from the bank to low water. The causeway has been lengthened and raised three or four times, and will have to be raised again. At Jenningtree Point, where 20 or 30 barges used to get sand, they cannot get it now, 1553–60, 1574–6.

Injury to Fish.—The best part of the river for fishing is Erith Reach. There used to be 25 to 30 boats fishing there, but now no fish can be caught between Greenwich and Gravesend. They began to decrease in the upper reaches about 16 years ago, 1524–30. Flounders, eels, whitebait, and shrimps, used to be caught by tons off Greenwich, 1535. The highest point up the river where whitebait can be caught now is the Lower Hope, but none has been taken in Erith Reach or Halfway Reach for at least 14 years, 1536–7, 1569–73. In taking live fish to Billingsgate, they must be taken out of the wells after passing Gravesend, until the sewage water is passed. They will live better on deck than in the sewage water. It poisons the fish. They can be replaced in the well (on the flood tide) after passing Greenwich, 1538–48. The well communicates with the exterior water, 1549–52. Gave up fishing in 1851, when he joined the Thames Police. The water at that time did not foul the nets, 1563–5. The Dutch eel-scoots, which used to come up to Erith, now lie at Holy Haven, and the eels are packed in trunks and sent up to London. They do not go up to the Pool with the eels in the wells, 1579–80. Attended a meeting at the "Golden Anchor" to discuss the evidence to be given before the Commission, but was not asked to speak "against the sewage," 1581–8.

## Mr. JAMES WILLIAM FARTHING, East Greenwich.

Waterman.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is a Greenwich waterman, and has been on the river 62 years, 1604–6. Before the outfalls were opened the water was very good,

## Mr. JAMES WILLIAM FARTHING—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

and ships used to take their supply of water for the voyage out of the river, principally at Greenwich, but also between Limehouse and Woolwich, 1607–12. They ceased to do this about 14 years ago on account of the impure state of the river, 1614–18, 1620. The water has been getting worse every day during the last eight or ten years, 1621–2, 1672.

Offensive Odours. — In summer time, when the weather is warm and calm, at high water the smell from the river at Greenwich is unbearable. "It stinks "awful." The discharge from the outfalls on the last of the ebb does not go down, but settles. When the flood tide runs up it carries the sewage with it and causes this bad smell, 1673–8.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—In hauling up an anchor, it is found always to be covered with a mixture of mud and greasy slime, which has an offensive odour, 1633–6. Along the south shore from the sewers to below Erith there is a deposit which, if stirred up with a scull, proves to be a mixture of mud and slime, 1636. There is a great deal less water in the river than there used to be down to Gravesend, 1637–8. [At this point a discussion took place between the chairman and the counsel as to formation of the mud banks in the reaches, which it is conceded exist, and reference was made by Mr. Bidder to the arbitration which took place between the Thames Conservators and the Metropolitan Board of Works as to whether these mud banks were caused by accumulations of sewage, and it was decided that they were not. Mr. Morice stated that he was going into the question of what the banks were caused by, and after some extracts from the report of the arbitrators had been read the examination of the witness was continued, 1639–50, 1653, 1658–60.] There has been a great increase in the banks of mud from Halfway Reach to Erith. It is not mud, but a nasty greasy soil, 1651–2, 1654–5, 1657. The banks used formerly to be made of "saltings," 1656. The deposit is in colour yellow and black, 1661–3. Twenty years ago there used to be 15 or 16 feet of water, while now there are not above 10 feet, 1667.

Injury to Fish.—The eel-boats used to lie off Erith before the outfalls were opened, and after that in two years they moved down to Gravesend, and then to Hole Haven, because the foul water killed the eels, though they are hard fish to kill. They will live longer out of water than they will in bad water, 1619–23.

## Mr. JAMES CLARKE.

### Bootmaker.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been a watchman at Price's oil works on the banks of the river, and can remember the river for more than 50 years, 1679–83. The river was pure before the outfalls were opened, 1684–5. Used to bathe in the river until he was twenty years of age, but it is not fit to bathe in now, 1688–90. Remembers the refuse from the factory running into a ditch which discharged itself into the Thames. The refuse now runs into pits, 1724–8. The factory is situated about 200 yards below Jenningtree Point on the south side, 1729. There used to be seaweed in the Thames just above Erith which was used largely for manure about 1855, but it has not been obtainable in large quantities the last 10 or 15 years; it is dwindling away, 1730–5.

Offensive Odours.—The river gives off an unpleasant odour, similar to decayed animal matters, which affected his health, 1698–9. It is worst during the hottest part of the summer, 1702. Has not noticed any unpleasant smells in connexion with Price's works unless it is from the smoke, as the fumes from the acids destroy any other smells. Has seen complaints in print on the subject, but attributes it perhaps to a desire to injure the firm. When the wind is in the east, it would carry the smell inland, 1715–19. The smells from the factory are quite distinct from the sewage smells, 1736.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The river has been filling up in different parts of the channel, both north and south, since the outfalls were opened, and if

## Mr. JAMES CLARKE—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

dredging had not been carried on, no ships of heavy draught would be able to come up, 1686–7. Thirty years ago there was hard dry sand from the lower ballast wharf at Erith to Jenningtree Point, but there is none now. It is "black slimy mud up to your middle," 1691–2.

Effect upon Health in the Neighbourhood of the Main Outfalls.—In 1867, when employed at Price's works, he fell from a barge into the water, and, when taken out, was much exhausted, and ill for several days from the effects of swallowing some of the water, which was in a very foul state, 1703–6, 1708–14. Has felt ill effects from the smell of the water when working alongside of the river on many occasions, 1698, 1707

## Mr. JOHN THORNE, Greenwich.

### Fisherman and Waterman.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Was formerly a fisherman, but is now a waterman, 1738–41. The river was in a very good state before the outfalls were opened, and the water was always used for drinking purposes. The smacks took in their supply at Barking, 1742–4, 1795. Now the water is very bad, very black, and very stinking. It has been so more particularly since the outfalls were opened, 1745–7. It was good as far up as London Bridge, and even further, except in 1852 or 1853, when the river was in a bad state, but nothing like it is now. Never heard any complaints of the condition of the river in those days, 1783–8, 1794. Now, between Woolwich and Greenhithe, if the nets are put into the river, they get covered with slime, and so they never put them in it, 1776–1777. There used to be red worms in the mud, but now there are none. They are all killed, he supposes, 1801–8.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—There is a great difference in the colour of the mud during the last few years. It is not mud, but more like slime, and very black. The Medway is clear, and not like the Thames at all now, 1778–82.

Injury to Fish.—Has left off fishing for nine years, but before the outfalls were opened Erith Rands was the best place in the river for fishing. There used to be 30 to 40 boats fishing there, but they have had to leave there and go down to Grays, Greenhithe, Gravesend, and the Lower Hope, about 15 years ago on account of the sewage, 1748–62. In taking fish to Billingsgate, they have to be taken out of the wells at Gravesend and placed in the boats to avoid the sewage water, which would kill them if left in the wells. They die at once if put into bad water, 1763–73. They can be put back into the wells off the Custom House at times if the water is good, 1766, 1774. The Dutch eel boats do not bring the fish up to London in the wells, but clear them out at Holy Haven, and are towed up to London as a rule, 1790–92. Comes up to Billingsgate once or twice a week, but his work now is to pilot small craft up the river, 1809–21.

## Mr. THOMAS PARKINSON.

### Trinity Pilot and Waterman.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been on the river nearly all his life, and remembers when the water was good and the shores clean mud. What was sand is now yellow green muck, and there are only nine feet of water in Halfway Reach where formerly there were 15 or 16 feet, 1826–30, 1881. Colliers and coasting vessels used to "bring up" on the south shore, but there is no water for them now, 1831–32. As an apprentice always drank the Thames water, and outward-bound ships took their supply of water from the river. It is rank poison now, 1833–41.

Offensive Odours.—In heaving up a ship's anchor, the smell from the river is noticeable, and in towing up astern of a tug or on a steamer, the smell is bad enough to choke you. It is worse in hot weather than in cold, 1864–65, 1869. The worst places are Halfway Reach, Tripcock, Woolwich, and thereabouts, 1870–72. Also in Long Reach, 1880. No one can go up or down without smelling it, 1872.

## Mr. THOMAS PARKINSON—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—In getting up an anchor, there will be plenty of "muck" on it as well as on the chain, and it is necessary to place a man in a boat forward with a broom to wash both the chain and anchor as it comes in, otherwise the deck would be smothered with it. The smell from the deposit is very bad, 1847–55. It has been getting much worse of late years. There is less water all the way down; and it is due to the accumulation of mud or muck from above the outfalls down to Long Reach, 1856–59. Where the barges used to get sand at Jenningtree Point is covered with this filthy deposit, 1860–61. The deposit at Erith Causeway is soft muck of different colours, 1862–63. Long Reach, Erith Reach, and Halfway Reach have silted up, and the deposit on the sides at low water is a sort of brown colour. It extends as far as Gravesend, 1873–7. Vessels which used to ride in Halfway Reach on the south side cannot do so now, as there is only nine feet of water, where formerly it was fifteen feet deep. But there is more water on the north side, as the shelf at Dagenham Dock has been removed, 1881–7.

Set of the Tide. — Sewage, he believes, can be taken up to the Pool, as the flood would take it up farther than it goes on the ebb, 1843–6.

Injury to Fish.—Fishermen used to be seen on all parts of the river, and 30 years ago they used to catch whitebait off Greenwich and send it to London, but no fish would live there now 1866–68.

Bathing.—People used to bathe at Gravesend, but there are no bathing machines there now, nor have there been any for a long time, 1878–79.

## Mr. WILLIAM BRILL, Woolwich.

### Fisherman.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Before the outfalls were opened, the river was in a very pure state, 1930–1. Twenty years ago was in the habit of drinking the river water between Erith and Greenhithe, but has not done it lately because it is not fit to drink, 1955–7, 1995–2005. The water when the sewage is discharged into it is of a very greasy nature, and has a different colour, a sort of green greasy nature to look at. It would very soon rot the nets if worked in the sewage water, 1964–9.

Offensive Odours.—Has noticed a very bad smell from the river at Erith, which can only be compared to the smell from a cesspool, but has never felt any ill effects from it, 1951–3. In going up and down the river has frequently to keep his handkerchief to his nose on account of the stench, 1954. In hot weather it is worst, 1981–3.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Prior to the discharge of sewage, the shore on the south side of the river was quite clean, and the fishermen could work their nets along the shore and catch large quantities of fish. Now the shore is all "slushy muck," smelling very strong, and nothing can live on it, 1938–42. There used formerly to be plenty of water in Church Hole, and now it is quite shallow with a "slushery" mud. It has been getting worse every year, and is increasing fast lately all along Erith, 1946–8. If the deposit is ever washed away it very soon appears again, 1949–50. The mud in the river is totally different to what it used to be. It was at one time hard pure mud on which you could walk, now it is slushy, and would come up to your middle if you got into it, 1977–80.

Set of the Tide.—The tide sweeps round Jenningtree Point and down Erith Reach, and settles in Erith Bight principally, 1943–5. The sewage at the farthest would not reach beyond the lower end of Gravesend Reach. Judges this because they have to remove the fish from the wells when they meet the sewage, 1958–9. Has seen lumps of sewage as well as in a liquid state floating in the river wherever the sewage goes. Has seen it above Crossness, 1970–2.

Injury to Fish.—Has been a fisherman nearly 50 years. The best fishing ground was from Greenhithe to Blackwall, but there have been no fish above Erith

## Mr. WILLIAM BRILL—*continued.*

Injury to Fish—*continued.*

since the opening of the outfalls. Now they have to go to Lower Hope, 10 miles below Gravesend, to get fish, 1929, 1932–4, 1984–7. Worms used for bait could once be found in the mud, but they have disappeared now, 1935–7, 1988–91. Fish cannot live in sewage water; they die at once, and on reaching the foul water the wells are emptied, and the fish placed in the boats, 1959–64. They cannot be put back into the wells until Greenwich or Limehouse are reached, 1972–3. Has not fished for a year, having lost his boat and gear, and has been unable to replace them, 1974–6.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Enjoys very good health, as he has not been affected by the smells from the river, 1953, 1903–4.

## Mr. GEORGE YOUNG, East Greenwich.

### Fisherman.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—The state of the water is so bad that unless the nets (which required tanning once a month) are tanned weekly, they would rot, and the boats' bottoms have to be scrubbed every time they come up, when formerly it was only necessary every three weeks, 2034, 2062–5. All the way down on both sides of the river the sewage poisons the water, killing the fish and the worms, 2047–9. The bottom of the river used to be sandy, but it is not the case now, 2035–70. An inch line, let down to sweep for a lost anchor, when hauled in, was found to be coated to a thickness of three inches with all manner of filth, 2020, 2083–6.

Offensive Odours.—The deposits in the river and on the banks smell dreadfully, more like a closet, and if you put your hands into the water it is difficult to get them clean, 2023–4. The smell is noticeable at Erith and in the Reaches above, 2081.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The bottom of the river is nothing else but filth, and there is the same deposit on the south shore from Jenningtree Point, 2020–2. Has shoved a staff six or eight feet into the filth in the Bight, 2037. The Erith Causeway has been lengthened in consequence of the great increase of deposits during the last few years. Used to moor their boats to the Causeway but cannot do so now. No anchor would hold with any wind, because the bottom is all "slather,' 2038–46. In Halfway Reach the "banks" are clean because they are intended only to prevent the water from going into the marsh and are not reached by the mud, 2050–2, 2079. The saltings are astride the banks, 2077–8.

Injury to Fish.—Has fished for 40 years. Before the outfalls were opened used to catch fish up at Greenwich and down to Erith. The best fishing ground was Erith Rands, 2006–10. Two years after the sewage came into the river they were driven down by degrees to Gravesend and Lower Hope, and now they have to go to the Medway, 2011–16, 2019. No fish are caught higher up than Lower Hope, 2017. In Long Reach the fish have to be taken out of the wells on account of the sewage. It makes them like drunken men. They are put back again in the Upper Pool, 2027–30, 2081. Salt-water fish will live in *pure* fresh water, 2331–3. Fish will not live at Gravesend now, and their absence is the indication of sewage. They might be caught perhaps a mile and a half lower down, 2058–61. Tried to catch fish off Grays a short time ago, and the baits came in on the hooks untouched, but covered with filth, 2073–6, 2083–6.

Effect upon Health in the Neighbourhood of the Main Outfalls.—When about Erith cannot stand the smells. They make him sick and he is obliged to keep his handkerchief to his nose, and take brandy to remedy the sickness, 2054–7.

Set of the Tide.—The sewage is carried down as far as Gravesend with the ebb tide, and witness forms this opinion from watching the fish in the wells and the effect of the foul state of the water on them, 2025–9.

## Mr. THOMAS HARRY SIBLEY, Erith.

Foreman and Lighterman for Messrs. Pigou and Wilkes.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—His duties are to see craft loaded and unloaded in Magazine Creek, just below the outfall, 2087–9. The river there is in a filthy state, owing to the refuse that comes from the outfalls, which smells like dead bodies floating about, 2090–4. Has known the river twenty-four years, and before the outfalls were opened there was only mud, or rather sand, there, 2118–20. Has often noticed sewage on the water, and has seen grease taken out of the river, half a hundredweight at a time, and believes several people get their living by it. It is generally collected at high water when the wind is on the land. The discharge generally commences about high water, 2132–8. Has never noticed any discharge of refuse from the factories or gasworks, 2182–6.

Offensive Odours.—The river in hot weather is very offensive, emitting a rotten sort of smell, 2092–5. The deposits in Magazine Creek, which are entirely due to the discharge from the outfalls, smell very bad, 2115. Denies that the smell in the river is due to the different factories, as they discharge no refuse into the river, 2153–6. The gradual increase in the smell is not to be attributed to the yearly increase in the number of factories, as the smell from them goes on all the year round, and is totally different to the smell from the river, which is strongest in hot weather, and is due to sewage, 2157–75, 2179–81.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—In Magazine Creek there is a deposit of "slush" (which is nothing but sewage) increasing every day. When the outfalls were first opened, it was not necessary to cleanse the creek with a sluice more than once in three months, but for the last ten years it has had to be done every fortnight. If left for six months the "roadway" into the creek would be blocked by the accumulation, and the creek would not be navigable, 2096–2113. Church Hole has been filling up with sewage deposits, causing an eddy tide, and preventing large ships from anchoring there, as in former days. The accumulation has increased very greatly during the last few years, 2122–31. Believes the set of the tide is the same now as before the dredging took place at Coldharbour Point, 2190–1.

Effect upon Health in the Neighbourhood of the Main Outfalls. — The smell from the river in hot weather is so bad that he, and others, have had to leave their work for a time, they have felt "so queer," 2116–17.

## Mr. WILLIAM HENRY JOSEPH McKEE, Erith.

Lighterman.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is foreman and lighterman to Messrs. Berry and Edwards, and works principally at Messrs. Curtis and Harvey's Magazine at Jenningtree Point. Has been on the river eighteen years, and with his present employers ten years, 2192–9, 2201–02. Ten years ago the river was in pretty much the same condition as it is now, 2200. At high water the river is all dark fluid, and floating masses come away from the sewers, owing to an eddy inshore. This happens every day, and the water is brown and thick at these times. Solid, as well as liquid, matter is seen floating about which gives off a very offensive sickening smell, and the barges are covered with slime, 2203–18, 2220.

Offensive Odours.—Offensive smells come from the factories in the localities, and can be smelt nearly every day. It depends on the direction of the wind what you smell; but these smells are totally different to the smell from the river, which is worst in hot weather. It is not so perceptible in the winter, 2221–49. Thinks he noticed the smell on about fifty and sixty days last summer, 2250–5.

Effect upon Health in the Neighbourhood of the Main Outfalls.—The smell does not affect his health much, or his appetite, though when the smell is great, and the sewage is being discharged, it is unpleasant, 2256–7, 2260–1. The men employed on the barges complain a good deal of the smell, and the slime on the sides of the barges, but they have not been obliged to knock off work on account of it. They have pretty good health, 2258–9, 2211–12.

## Mr. JOHN GODFREY LEE, Erith.

Waterman to the Corinthian Yacht Club.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has known the river about Erith seven years. It is very bad at the last quarter-ebb there. An eddy tide runs up for about an hour at half-ebb, and then runs down again, thus bringing the sewage down to all parts of the shore about Erith, 2262–9. The Club causeway is private property, and was built about three years ago, 2318–19. Yachts, which formerly lay off the old pier and other places, now lie off the Club House in Church Hole, owing to the filthy state of the river, 2318–26.

Offensive Odours.—A very bad stench rises from the sewage deposits at Erith, which, on a warm morning, is so powerful that it takes away your appetite, 2270–71.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—In calm still weather, actual sewage is deposited in Erith Bight by the tide in large quantities. It has greatly increased during the last seven years. The direction of the wind does not affect the deposit much, 2273–8. The Club Causeway runs down to the river about 350 feet. In hot weather, at low tide, it is not fit to walk on, unless scrubbed down every day, because it is covered with slime and dung. This deposit is left there all the year round as a rule, but the stench and smell are enough to choke you. A boat's bottom will get coated with it in one tide, and they have to be cleaned and re-dressed four or five times every summer to keep them in proper order, 2281–91. A strong north-east wind will sometimes cause a decrease in the deposit to the extent of four or five inches, but, on the other hand, in still weather, it will accumulate to the same amount in a week. At high water, in a gale, the surface of the water is as bad as the bottom, 2292–3. The mud on the shore is like grease, and "slicker." It is difficult to remove it from your clothes or boats, 2294–5. The "mud" does not accumulate very much at the Club Causeway, but it is "slickery" stuff, 2313–17.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has often had headaches and sickness from the smells in the summer time, but it does not affect him in the cold weather. His wife and daughter have suffered from the smell, and are obliged to go away during the hot weather. His son's health is not affected at all, 2279–80, 2298–305.

## Mr. WILLIAM HOSKINS, Erith.

Lighterman.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has known the river for 40 years, and the water was clear and fresh before the outfalls were opened, and fish were caught between Greenwich and Erith. For the last 14 years that has not been the case, 2327–36. Is aware that four or five drains or sewers, which come from butcher's premises and others discharge into the river at Erith, 2394–6, 2408*a*–9, 2414–6. Has noticed the alteration in the colour of the water at half tide when going up and over the river. It is like black filth, 2345–7, and in rowing a boat through it, it is like a lot of mud, 2350.

Offensive Odours.—There is a very bad stench from the river, frequently about half ebb tide, which he has noticed in Halfway Reach, 2349–50. At Erith the deposit caused by the sewage smells very bad. It is noticeable on the shore from the sewage in the water, 2397–400. It is perceptible at all times of the year, but is worse in summer than in winter, 2410–13. There are plenty of other smells up and down the river from factories, but they are quite different to the sewage smell, and are easily to be distinguished. The sewage smells far worse than the factories, 2401–8.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Along the Halfway Reach and Erith Bight there is a great deal of filth on the shore. It is not mud, but it is grease, without much smell, and has increased considerably during the past few years. It is principally in the Bight between Church Hole and Erith Causeway, and is four or five inches deep. Remembers when he could get into his boat, at low water, with three steps, but now cannot get within five boats lengths at spring tide, though the causeway has been lengthened 60 feet, 2363–72. In hauling ropes into his boat they are coated with grease, 2390–3.

### Mr. WILLIAM HOSKINS—*continued.*

Injury to Fish.—Up to nine years ago there were large quantities of mud worms which were used for bait between Erith and Woolwich, but there are none left now. Fishing boats used to come up to Greenwich, but now they have to go below Gravesend to fish, 2331–44, 2375–8.

Set of the Tide.—Three years ago he made an experiment with bottles to test the distance the sewage travels from the outfalls. Bottles put in at Crossness on a strong spring ebb and westerly wind drifted down to the "Lobster" at Gravesend, 2352–9. That would be a distance of 13 or 14 miles, and the time occupied was about six hours (the whole ebb), 2380–9.

### Mr. CHARLES FAULKNER, West Street, Erith.

Contractor.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has lived at Erith 63 years, and his work has been chiefly connected with the mud of the river, 2429–34. Twenty years ago it had a pure salty smell, but it began to alter 16 years ago, and smelt badly, driving the fish away, 2437–9. In summer time, after working in the mud, it requires four or five washings to remove the smell from your hands, 2441.

Offensive Odours.—His work is to lay the berths level for the barges at Price and Harvey's oil works, and the smell from the accumulation of mud on the berths is very bad. It is worst in the summer time, 2462–4, 2510–12. Has smelt the water from the banks of the river, 2515–20.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—There is an accumulation of black mud on shore at Erith to a depth of one foot and a half, which has increased for the last 20 years, and smells like night soil, 2442–7. There is not so much water between the club-house and the old pier by eight to ten feet, 2447–51. This black stuff settles in the bight, and the water is slack. There is also an eddy-tide, 2452–7. Has considerable difficulty in clearing away the mud from the berths, and has seen the sewage intact deposited on the berths. Sometimes it is necessary to clear the deposits on the berths, two or three times a month; and he does this when the tide is running down, so that it sweeps the stuff away, 2465–7. There are two reservoirs by the wharves which fill with the tide, and when the tide falls the "flap" shuts, and the water remains. A sluice gate is then opened to let the water out, which washes away the accumulation of mud. They were made 18 years ago, 2479–94. The old reservoirs, which were made when he was a boy, have been done away with. Their object was not so much to clear away mud, as to keep the beds clean, 2494–2508, 2521–3.

Injury to Fish.—The opening of the outfalls caused bad smells in the river which has driven the fish away. When a boy, remembers trawling off Erith and catching plenty of fish, 2433–40.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Enjoys pretty good health, and, with the exception of gout, there has been no difference during the last twenty years, and the time preceding it, 2469–74.

### Mr. WILLIAM HARLING, Erith.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has worked at the ballast wharves for twenty years, and when he first went there the water was clear, and fish were caught at that time, 2524–7.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—During the last fourteen years there has been an accumulation of black greasy filth along the shore, which has got worse lately. It sticks to your finger nails if you try to wash it off, and stinks, 2537–41. Large lumps of human manure float down the river and remain on the sides of the dock, 2542–3. Has to keep the berths clear where the ships come to take in ballast, 2544–6. The filth settles on the steps as the tide goes down, and also on the banks, 2552–6. The docks where the ships lay alongside the wharves have to be cleaned out by means of reservoirs every tide, 2557–60. The reservoirs have to be cleaned out every other week to remove the mud and "slurry," 2574–8.

### Mr. WILLIAM HARLING—*continued.*

Injury to Fish.—Twenty years ago Erith was a good fishing place, and sometimes a hundred baskets of fish being caught on a Monday morning. The boats stopped coming up fourteen years ago, 2547–56, 2571–3.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Every time he goes into the dock to clear out the "mud" he has to go to a doctor. He feels sick and "faintified" and short-breathed after it. This has been going on for the last three or four years, 2547–50. Never felt it before, 2551. The dock is a sort of mud berth alongside a staging, which is a ballast wharf, 2561–9. One of his mates is similarly affected. Previously enjoyed very good health. The doctor attributes the illness to working in the dock, 2579–96.

### Mr. HENRY CLARKE, Erith.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Has worked at the ballast wharves in the employment of Mr. Parish all his life, 2598–2601. Has to work in the mud occasionally, on the top of which a nasty black filth, resembling "stuff from the human body," settles, 2605, 2609. It has increased in quantity as well as in kind of late years, 2620–21. The reservoirs have to be cleaned out once in every fortnight, at spring tides now, as against two or three times a year when they were first made, 2622–6.

Offensive Odours.—The "mud" has a nasty smell rising from it, and there is also a bad smell from the adjoining wharf, where dung is brought down in barges and carted away. Has never worked there, 2609–10, 2627–35.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has felt ill effects from working in the mud, "a nasty faint sickness," more now than formerly. Working on it before breakfast takes away his appetite completely, 2601–8, 2612. Has had to go to the doctor for medicine about four times, but has never been laid up, 2610–18, 2637–42.

### Mr. WILLIAM GATWARD

Constable.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been stationed at Barking Creek about twelve years, about seven hundred yards from the northern outfall, 2643–5. The river in that vicinity is very low, and smells very bad indeed. There is also a quantity of refuse, such as fat, and bullocks' lights, left on the shore, which smells, and in hot weather is unendurable, 2646–7. From his station can see the sewage discharged from the outfall and run into the river. Its progress is marked by the colour on the water, 2652–58, 2814–15. Has seen large lumps of fat floating amongst the sewage on the river, and seven men get a good living by skimming the river and melting the fat down. It is known as "Thames mud butter," and is used for lubricating purposes. Describes the process of collecting and melting down, 2661–3. The lights he has noticed in the sewage about 300 to 400 yards from the outfalls almost every tide, but more particularly after a heavy rain, 2664–7, 2759–61. Believes the sewage of Barking is discharged into the Creek, 2760 to 2762. Is not aware of any refuse having discharged from the paper mills in the Creek or from the Barking Gasworks, 2763–6. Has had to row with a strong rippling discharge coming from them, 2767–8.

Offensive Odours.—There is "a very foul, nasty, sickly smell" from the mud left on the shore, 2661–2. Has also smelt it on other parts of the river, in some places it is very bad, you cannot stand it and is glad to run the first chance to get away from the smell, 2662–3. Has traced the smell as far as Greenwich when rowing for pleasure, 2763–4. The smells from some of the factories are very offensive, but is quite different from the river smell, 2764, 2769. Has heard the people living at the creek complain of the smell, 2765–67. At the mouth of the creek, by the railway, which runs down to low-water mark, there is always a smell from the river, 2768–74.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The mud or deposit left by the tide is almost black, and is greasy stuff, 2649–51, 2677–81. And large quantities of

MR. WILLIAM GATWARD—*continued.*

POPULAR EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS—*continued.*

it remain on the causeway, 2659–64. On the foreshore below Barking the top of the mud is a greenish colour, 2673–5, 2737–9. The bodies of those drowned by the "Princess Alice" collision, when recovered, were in a most beastly state, their clothes being covered with slime and filth, which gave off an intolerable smell. Has never seen bodies in such a state anywhere but in the Thames, 2665–72, 2762–79, 2801–12.

INJURY TO FISH.—Has seen plenty of fish at this time of year after heavy rains come down, and directly they reach the water, which is contaminated by sewage, they die. Only a week ago one hundredweight of eels were picked up dead on the stones just outside Barking Creek, extending to half a mile below the outfalls. Has never seen live fish there. They become stupefied and can be picked up, 2682–6. It is a common thing to get eels in the neighbourhood of the outfalls at this time of the year, 2781–9.

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS.—The smell arising from the mud and sewage in hot weather has often made him feel quite sick, 2647–8.

DISCHARGE OF SEWAGE FROM THE MAIN OUTFALLS AT IMPROPER TIMES.—Has seen the sewage come out from the outfall before high water, and also running up after low water, when the flood tide is flowing, on several occasions, 2653–7. Has noticed it this year, on the 25th August, running up on the flood towards Beckton. It is a different colour to the water, 2704–25. Can see it from his station on the wall, 2818–20.

## MR. GEORGE ROBERTS.

Inspector of the Thames Police.

POPULAR EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—Has known the river between 30 and 40 years, and has been stationed off Erith for four and a half years. When the outfalls were opened he was at Blackwall, and has been quartered at different parts of the river as constable since 1860, as far up as Putney, 2821–24, 2826–34. Prior to that, was for 18 months in the Customs, and, in fact, has been on the Thames from his boyhood, 2835–41. Before the opening of the outfalls the water was in a very good condition, but it has been very bad since, such bad smells emanating from it, 2825, 2842–43. When in the Customs service, at low water, they used always to "dip" for their water to use in the boat, but they cannot do so now, it is so dirty and smells, and it is unfit for washing or drinking purposes, 2873–9. Has taken it out at Erith, but seldom below, as it becomes brackish there. It was quite suitable for washing and cooking, but not for drinking, at Erith. As a rule, Woolwich used to be the general place for "dipping" for drinking water, but has heard of smacks taking in their supplies of water at Barking Creek, 2880–6. In the bays and slack water there is frequently lots of fat and slaughter house refuse floating about, 2910. His "beat" is from Dartford Creek to Beckton, and is on the river at all hours, morning, noon, or night. The police vessel is moored off Erith Pier, 2953–64. When rain and fresh water come into the river, when the water has been very bad, it is sweetened a little, 2996. Can always tell when the "freshets" are down by the colour of the water, 2998–99.

OFFENSIVE ODOURS.—Has noticed bad smells coming from the river in hot weather, when the water is still most particularly, and also in close foggy weather, 2844. A steamboat stirs up the water, and makes it smell, 2867. By direction of his superintendent, he took notes of the state of the river from the 1st to the 4th August 1880, and noticed bad smells coming from the river. His report can no doubt be produced from the Commissioners of Police, 2929–52. The smells are like "rotten soap suds," a nasty filthy smell, and are most prevalent in Barking Creek and Halfway Reach. They are from the river, and has never noticed the smell on the land, 2965–70. Smells it when he is afloat, 2848.

POPULAR EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—The bodies recovered from the river after the "Princess Alice" disaster were terribly swelled, and in a decomposed state after being a very short time in the water, only two or three days, not more. Is unable to say whether there was

MR. GEORGE ROBERTS—*continued.*

POPULAR EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS—*continued.*

any mud or deposit on the clothes, as he did not notice their condition, 2849–56. The mud on the foreshore above Erith looks terribly black and dirty, and smells badly at times when there is a wash on the shore stirring it up. It extends from Dartford Creek up past Erith as far as the Northern Outfall, 2857–63. For the last three months the mud appears to have been drawn off the river shore, as it does not lie so thickly on the shore as it did, 2863–66. Has "seen quantities of round "balls and the likes of that" "lying about on the "stones on the shore—greasy stuff, all up and down "on either sides of the river banks," 2908. The diminution in the deposits of mud has been considerable lately, and it appears to be accumulating towards the bed of the river. When rowing at low water, the oars stir up the mud 20 or 30 yards from low-water mark, 2972–3, 2986–8, 2994–5. The mud at Erith is of a bluish brown colour, and is darker at the mouth of Barking Creek. There is very little difference in it on both shores, and it is quite different to the mud at Greenhithe or Gravesend, 2974–85. The dredging machines at work in Long Reach bring up ballast and gravel principally, 2989–90.

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS.—Has never been laid up, but has felt very sick from the smell when rowing about, especially when under the sterns of steamers, and also when the water is very still. Lives about a mile inland, 2845–7. One of the men under him was returned sick this year, and obtained leave of absence, as he was suffering from diarrhœa, which the doctor said was "probably caused by the bad smell from the river," 2912–19. Has four men under him, 2920. Cannot tell without his books how often the men have been off duty from sickness. They are, like himself, pretty strong, and not very sickly, 2991–3.

DISCHARGE OF SEWAGE FROM THE MAIN OUTFALLS AT IMPROPER TIMES.—On the 1st August 1880 noticed the discharge of sewage commence at Crossness at 9.30 a.m., *go up the river* with the flood. It was high water at London Bridge at 9.53 a.m., or half an hour's difference between the outfall and London Bridge. The sewage was flowing up at Barking at 10 a.m. the same day, 2887–91. On the 2nd received a report from one of his men that the sewage was *flowing up from the southern outfall*, and saw it himself do so from Barking. The same thing happened on the 3rd August, and on the 4th the discharge began about the time of high water at London Bridge. These observations were made by direction of his superior officer, 2892–2900. Has noticed it come out on the flood on other occasions, but not recently, 2901–2. Has seen the sewage a long way up the river above the outfalls. At Woolwich has seen the water quite black, and on his rounds has traced it up the tideway from Erith to Woolwich, 2903–6. When the water comes to its highest point adjoining the bank, it continues to flow from a quarter of an hour to half an hour, and the sewage discharged at high water would go up the river, 2921–5.

## MR. EDWARD ARUNDEL CARTTAR. Greenwich.

Coroner for the County of Kent.

POPULAR EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—Succeeded his father as Coroner two and a half years ago. His district extends from Rotherhithe to Gravesend, mid-stream, and to the north side of mid-stream in the parish of Woolwich, 3000–6. Has held over eight hundred inquests, out of which 156 have been on bodies taken out of water, and 98 of these were drowned in the Thames, 3008–10. In 1881 held 32 inquests on bodies recovered from the Thames. The inquests are held in the parish in which the body is recovered, 3011–12. There is a marked contrast between those bodies taken out of the Thames and those taken from other waters. The bodies of the former are very much disfigured and discoloured, by the gas, he presumes. They turn various colours, and decomposition is very rapid in the summer, particularly in those cases which are found below Charlton. Two or three days are sufficient, 3013–14. Very often the bodies are covered with a deposit of mud and filth, and there are complaints about it. The matter has a very offensive smell, 3015–19. Bodies recovered from the Surrey Canal are comparatively clean, with but very little mud on them. From

## Mr. EDWARD ARUNDEL CARTTAR—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

the Albert Dock there is a slight deposit of mud on the bodies, but has not noticed any offensive odour or smell arising from it, 3020–5. From Charlton to Erith the bodies are in the worst condition, 3026–9. A man was drowned on the 16th July off Tripcock Point, and his body, when recovered five days after, was in a very bad state, disfigured and swollen, and covered with filth and slime. It was strongly commented on by the Jury, though they are used to bad cases, 3034–42. Has known the river about twenty-six years, and it has greatly improved of recent years from Greenwich and above; but below Greenwich it has become much worse, 3030–3. Any report in the local paper representing that he alone, and not the jury, made remarks on the state of the river after the inquest in July, is incorrect. A witness, Mr. A. Collins, has often made complaints as to the state of the river, 3044–49, 3068–78. Taking into consideration the difference of time in recovering bodies from the river, and those drowned in ponds, &c., there is a marked contrast between the condition of the bodies, 3051–6. So far as his observation goes, the state of the river below Greenwich is worse now since the outfalls were opened than it was before, 3057–67, 3080–2.

## Mr. GEORGE MASTIN.

Thames Police, Erith.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been on the police boat at Erith three and a half years, and on the river about twenty-five or twenty-six years, 3083–6. Before the outfalls were opened the river between Crossness and Gravesend was much purer, and there was not the foulness in the water that there is now, nor did it smell so bad. Is on the river daily, 3087–91. The river water is used to wash the decks down with, but it cannot be used for any other purpose on account of its foul state. At times they have to skim the grease and slime from the surface of the water to get at the water underneath. Attributes this to sewage or the contents of sewers, 3100–3105. Dead bodies when taken out of the Thames are generally in a very decomposed state, and a recent case, after four days' immersion only, was very decomposed, 3106–11. Some of the bodies which were recovered from the river a few hours after the "Princess Alice" disaster had a reddish appearance and were discoloured, and froth was coming from their mouths, 3120–9. Has been in the Thames police about fourteen years, and stationed at various parts of the river between London Bridge and Gravesend, and prior to that he "served his time" on the river steamboats running between London Bridge and Sheerness, 3130–44. Has not seen any discharge from a drain or sewer at Beckton, nor any refuse flowing into the river from the gasworks there, 3146–64, 3183–4. There is a great difference between the state of the river now and what it used to be, 3185–6. The distance from Beckton pier to the northern outfall is from 300 to 400 yards, 3187. As a rule the discharge from the outfalls begins about high-water time, but has seen it come out a little before high-water and go up with the flood. In rowing down, has met the sewage coming up just below Halfway House. It is very black; has a most offensive smell, 3112–17.

Offensive Odours.—The smell from the mud on the foreshore between Erith and Beckton is very offensive, 3098.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—The mud on the banks has "a yellowish slimy look about it," and is not a sandy soil, as it used to be in former years, 3093.

Injury to Fish.—Remembers as a boy seeing the Dutch eel-scoots lying off Erith, but it is from seventeen to nineteen years since they discontinued coming there, 3118–19.

Effect upon Health in the Neighbourhood of the Main Outfalls.—At times has been obliged to leave the boat in hot weather on account of the smell from the water. Twice it has caused him to vomit, 3099. Once, when cleaning out the boat at Erith Pier, he had to go ashore and get some refreshment at a public-house as he felt so sick and faint, and did not go on duty again that day, 3165–82, 3188.

## Sergeant CHARLES GILHAM, Woolwich.

R Division of the Metropolitan Police.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been in the police force for ten years, and was coroner's officer for five years; before that he was in the navy, 3193–5, 3240–1. During the last ten years the state of the river has been very bad indeed, thick and dirty, with a very bad smell in hot weather, especially when the penstock is opened at North Woolwich, 3196–8. The "Princess Alice" bodies, which were recovered within twenty-four hours of the accident, were covered with slime and mud, large black blisters came on the skin, and they smelt very bad indeed. Those recovered later were much worse, 3199–3205. The clothing, which was saturated with sewage and slime, had to be boiled and disinfected in order that it might be identified, as the bodies were in most cases unrecognizable. Without this process the clothing, from its filthy state and bad smell, would not have been in a fit condition to show for identification, 3206–20. The blisters were full of black liquid and are of immense size. Bodies recovered in other waters do not decompose so rapidly, and turn green, not black, at first. If a body is taken out near Gallions Reach, or off Beckton, it will turn black and blister in seven or eight hours after being washed, 3221–33, 3261–5. Off Charlton they are not in so bad a state, 3236–49. Believes some of the refuse from the Beckton gasworks is discharged into the river, 3234–5. When the penstocks at North Woolwich are opened the water is discoloured for a considerable distance, which in warm weather smells very badly. The sewage from North Woolwich and part of East Ham is emptied into the river at this point, 3250–60.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The causeway at Woolwich has to be washed down as the tide recedes. It is very slimy and slippery, and covered with filth, generally black mud, which, in hot weather particularly, is very offensive, 3222–4.

## Captain GEORGE BENJAMIN LYNCH.

Principal Dockmaster of the Albert Docks.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has known the river for forty years, and it used sometimes to be bad and sometimes pretty good. Steamers used to "dip" for water off the Custom House. In summer it was a little bad, but at other times it was very clear, 3267–9. Since the outfalls were made the water has been thicker, and the accumulation on the banks is blacker between the Victoria entrance and the Gallions entrance. It smells very much in hot weather, but not much in the cold season, 3270–4. The water is now quite unfit for use on account of its dirty condition as well as for the oily appearance of the surface at times, 3279–84. Has frequently noticed solid matter floating in the water, "filth" from the closets and that sort of thing," and has seen the sewage passing up the river, showing black streaky marks in the tideway, about half flood-tide, 3285–90. It is in fact a discolouration of the water, and is most noticeable in hot weather, 3332–4. Has heard of the "overflow water discharge," but not of any sewage discharge from the penstock at North Woolwich, 3335–8. Knows of no arrangement for getting rid of the refuse from the gasworks at Beckton, nor has he ever seen a sewer there, 3339–41.

Offensive Odours.—Smells are given off from the factories in the neighbourhood, but there is difference between the smell from the works and the sewage, which he is able to distinguish, 3299–3303.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—There has been a considerable accumulation of mud in the basins of the docks during the last two years (since the docks were opened), and on the flood tide black water can be seen coming through the piles of the pier heads, 3275–7. The mud is blacker than it used to be, and smells very much, 3297–8. Has compared the mud with that at the Victoria Dock entrance, which is higher up the river, 3310–14. The two entrances are from two-and-a-half to three miles apart, 3315. The Albert dock entrance is three-quarters of a mile, and the Victoria entrance is about three miles, from the northern outfall, and the mud accumulates in both basins faster than it used, 3316–18. There is an eddy on the ebb-tide at the Albert entrance, but the two pier

## Captain GEORGE BENJAMIN LYNCH—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

heads which were erected, and run out into the river, for the purpose of docking ships, do not keep the mud out, 3319–22, 3342–4. There was always a deposit of mud in the Victoria Docks since they were opened in 1855, and it has had to be dredged up and sent away in barges, 3323–6. For a long time has had to dredge the basin out every three months, 3348. Has been connected with the Victoria Docks since they were opened, 3345 Dredging in the Albert Docks basin began last month, and it is quite a new dock, 3346–7.

Injury to Fish.—Has frequently seen dead fish on the banks of the river, more particularly in the summer time. They are to be seen wherever there are eddy tides, at the time the flood is running up, 3291–5. There used to be a great many fish in the Victoria Docks, and jack were caught there, but now there are none, and he has not seen any people fishing in the Docks for five or six years, 3327–31.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has known the men to complain of the smell of the water in the docks sometimes, 3278, and has seen them sick from it, but has not felt much ill effect from it himself, as it affects some people more than others, 3304–6.

## Mr. JAMES HENRY SHOWELL; Greenwich.

Inspector of the Watermen's Company.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—His duty is to board barges and craft on the river to see that the Act of Parliament is carried out, and has been on the river 24 years, 3350–55. Is 38 years old, 3400. There is a very great difference in the water of the Thames since the outfalls were opened. It is in a filthy state; there is a great amount of sewage in it, and it both smells and is discoloured. It was worst in the summers of 1880 and 1881, 3356–61. Has noticed the sewage in the river, specially by the thickness of the water, by the mud, and by the dreadful stink there is attached to it, 3362–63. The smell is worst in Woolwich Reach on the north shore, just as the tide is making. Has frequently seen sewage matter and other things come out of the sewers and floating in the river, 3384–5. In Sea Reach the water is very clear, especially on the flood tide; but it gets thicker as you go higher up, until you arrive at Limehouse Reach, when the water becomes clearer. The change is noticed first at Lower Hope, coming into Gravesend Reach, 3394–6. The Penstock at North Woolwich is about 600 yards above the ferry pier, but has never seen sewage discharged from it, because the sewer is under water at low tide. Has heard no complaints about it, 3424–8. Has never seen any discharge of sewage coming from the Beckton Gasworks, but he has smelt the gas liquor as the barges were being loaded with it, 3429–33. Believes there is a discharge of sewage into the river at Gravesend, but does not think it would account for the discolouration of the river there, as the sewer was there when the fishing boats lay there, and it never affected the eels, 3457–8.

Offensive Odours.—The most distinct and offensive smell from the river is on the north shore at North Woolwich, close to the pier, and just at the time of the young flood, 3421–3. The smell from the mud has greatly increased since the outfalls were opened, 3399.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Between Erith and Tripcock Point the mud on the south shore used to be of a whiter colour; now it is black, and stinks very much, 3364–5. Has frequently noticed a settlement of sewage along the shores in the different bights, which has increased in recent years, 3397–8.

Injury to Fish.—Used to work for the Dutch eel-boats off Gravesend 24 years ago, and bring the fish up to market at night, but has not done so for the last 10 or 11 years, 3366–71. The boats now lie at Hole Haven, in consequence of the advice given to them by the watermen, as the water is so bad, 3372–80. Does not recollect the boats stopping at Erith. His first voyage was made after the sewers were let into the river, and it was from Gravesend to Hole Haven. It was against the watermen's interest, pecuniarily, to recommend the removal of the boats lower down the river, 3401–14. Eels

## Mr. JAMES HENRY SHOWELL—*continued.*

Injury to Fish—*continued.*

can live in the pool. They are carried up in the wells, 3415–20. In winter there is plenty of fresh water in the river, which facilitates the transit of the fish up the river. In the summer they would not live if taken through the sewage water, and are brought up in boxes. If towed up in the winter, they are taken through the sewage so fast that it cannot touch them. The boats bring up about 12 tons each. The fish are better at low water than on the flood at Billingsgate, 3434–52.

Effect upon Health in the Neighbourhood of the Main Outfalls—In 1881 the smell from the river made him very sick, and he had to go ashore, and leave his boat. Has never actually been unable to do his duties, but has "felt very queer" nevertheless, 3386–88.

Set of the Tide.—From his experience of drifting in a boat, the sewage would drift on an ebb-tide to the lower end of Gravesend Reach, 3389–93. Has seen the water thick with dark matter down there, 3453–5.

## Mr. JAMES WILLIAM ROZIER.

Chief Inspector of the Watermen's Company.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been in the Company's service 18 years, and knows the river from Woolwich to Gravesend well, 3459–64. Since the outfalls were opened the water has become a different colour, and stinks, 3465–71. The bodies of people drowned in the Thames when taken out are black, and the clothes are covered with slime, 3472–5.

Offensive Odours.—In 1860 he used to take the fish refuse from Billingsgate to Dagenham to make manure with, and there was no smell from the river then. The only smell was from the fish. Now, when a steamboat goes down the river at low water, the mud is stirred up and smells, 3479–89.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The mud on the foreshore down the river is quite different from what it used to be, and is black as ink, with a very offensive smell in summer time at low water, 3476–8.

## Captain JAMES HUSSEY.

Principal Dockmaster of the East and West India Docks.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been at the docks for 32 years, and lives close to the Blackwall entrance to the West India Dock, 3501–2, 3548–50. At times, when there has been an accident to the Barking outfall, the sewage is pumped at Bromley into the River Lea, and it flows "in one solid mass" into the East India Docks, 3532–34, 3551–60. The Lea comes into the river just below the Blackwall entrance, 3560. The sewage in the water is very thick, but has not seen any solid lumps in it, 3601–3.

Offensive Odours.—On a still night, when the mud settles on the banks, the stench from it in summer time is something awful. There are no factories near his house on the land, 3509–10.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—There has been an enormous increase in the accumulation of mud at the entrance to the docks and in the docks the last few years. At first when the outfalls were opened the deposit was less, but it soon increased, and has since been steadily working its way up, 3503–7. In 1879, 69,000 tons of mud raised cleared the whole of the docks and basins, which cover an area of 120 acres. This year 90,000 tons of mud have been raised, and yet there is left an accumulation of 70,000 tons. Has been obliged to employ a contractor to clear one basin, as the mud has overpowered him. It has a large percentage of sewage mixed with it, 3508. Attributes the increase partly to the sewage having come up from the outfall, and partly to the exceptionally heavy tides, which have brought down a lot of land water and mud, 3566–73. Can detect the sewage in the mud by its greasy slimy state, its bad smell, and by the dark colour to which it turns. Formerly the mud was sand colour, but now it is black, 3523, 3586–91, 3605–6. The mud when raised from the docks is taken to the Company's station adjoining the Crossness outfall, where 12 men are stationed to remove it from the barges, 3593–9.

### Captain JAMES HUSSEY—*continued.*

Set of the Tide.—The sewage took nearly two years and a half to reach the docks from the outfall, but it is working up gradually, and it now goes up as far as Limehouse. He tested the mud and found it to be mixed with sewage. There is a deposit of sewage at the back of his house and in the locks, which is brought there by the tide a distance of eight miles from the outfall, 3514, 3521–2, 3524–7. Sewage is discharged about the quarter ebb from the outfall at Crossness, 3515–20. The flood tide is stronger than the ebb, though the ebb runs an hour longer than the flood, and consequently sewage is carried up by the flood to a point above where it is discharged. He believes that in 18 months' time from now the sewage will drift up to Westminster, 3528–30. The sewage works its way up the river at the rate of about three-quarters of a mile a year. This statement is derived from observation of the time the sewage has taken to work from the East India Docks at Blackwall in 1879 up to the Limehouse entrance to the South Dock in 1882, 3538–47, 3574–85.

Effect upon Health in the Neighbourhood of the Main Outfalls.—His family and his grandchildren have suffered from the smells, and were taken ill while staying in his house, 3511–13. Has heard that one of his men was ill from the foul state of the mud, 3537, 3592.

### Mr. GEORGE FREDERICK FULLER, Granville Park, Blackheath.

Member of the Firm of Messrs. G. and A. Fuller, Government Dredging Contractors.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—His premises have a frontage of 1,000 feet at North Woolwich, and the river there is in a filthy state owing to an accumulation since 1879 of 18 inches of "mucky, filthy, browny-red stuff," which smells awfully in the summer, 3656–8. The Thames water was always used for crane boilers, but they are now unable to use it on account of its filthy state. It causes the boilers to prime and adheres to the tubes, and so burns them out. Now they are obliged to obtain their supply from the water company, which is an additional and great expense, 3663–7. Has had a good many barges sunk, and when they have been raised they have a bad sediment of mud and sewage on them, which collects at the rate of half an inch a day. This is not found on barges sunk below Gravesend, 3670–3. Experiences some difficulty in getting men to work in emptying the barges. They always require a great deal of refreshment on account of the filth and the smell. The difficulty is greater when the dredgers have been working above Gravesend than when working below, 3674–7. River steamers use Thames water for their boilers, but they get clear water and condense it. Without this precaution their boilers would very soon be worn out, 3699–3702. The river water was sometimes very bad and black in summer before the outfalls were opened, 3682.

Offensive Odours.—The mud brought up by the dredgers has a very unpleasant smell, 3653, and the mud at North Woolwich smells horribly in summer time, 3658. Before the outfalls were opened the river smelt very bad sometimes, but there was no smell from the mud, 3680–2.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—For the last 20 to 30 years has been in the habit of dredging the Thames from Woolwich to Gravesend for ballast and sand. Used to get clear building sand and ballast at the different points down the river, 3609–12. For 12 months after the outfalls were opened he used to dredge at Tripcock and Jenningtree Points, but had to leave them and go further down to Coldharbour Point, where he worked for three or four years. They were driven away by the filth in the sand, and by degrees they have got down to below Gravesend, 3613–33. When a lot of water comes down from the upper river the mud is partly cleared away, and a few freights of sand can be got at the different points up the river, 3628, 3631. Was able to work at Crayfordness for 10 years, but it is very dirty now. The customers complain of the filth in the sand, and will not accept it unless clean, 3633–40. For the last four years has got sand between "Fiddler's Point" (Stoneness) and Coalhouse below Gravesend, 3642–6. The sewage is mixed with the sand, and the men have

### Mr. GEORGE FREDERICK FULLER—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

to wash it when it is brought up by the dredging machine to clean the sand, as well as allow as much filth as possible to run over the edge of the bag or bucket before emptying it into the barges. The sewage smells even when the mud is dry, and turns the sand black, 3647–52. Samples are sent to the firm to enable them to see the state of the mud, which has a most unpleasant smell, and they have just heard that the Gravesend sand was spoilt, being covered with filth to a depth of 18 inches, 3648, 3653–5. Dredging sand and dealing with the mud are two distinct businesses which the firm carry on, 3678. Before the year 1864 the mud was of a white colour, and had no smell, 3679–81. These accumulations of mud in different places form the mud-banks, which have been referred to by other witnesses. A barge sunk a fortnight ago was put ashore in four feet of mud, where a few years ago there was a clean hard shore, 3686–88. The accumulation of sand is caused more by the deposit from a flush, than from the sea sand brought up by the tide. There is no doubt that it fluctuates, but the increased traffic and consequent stirring up of the mud has nothing to do with it, because there are eight or nine feet of mud now where they used to get clean good sand, 3691–94. The deposit at North Woolwich has a coating of sewage on the top, which can be identified by the colour, 3695–8. The cost of the sand for building purposes has increased, owing to the distance you have to go to obtain it, but people prefer salt to sewage in the sand. Gravesend sand is very free from salt, owing to the fresh water coming down, which purifies it. The sand can only be obtained at ebb tide, 3706–12.

Effects upon Health in the Neighbourhood of the Main Outfalls.—For two summers, in July 1880 and 1881, when the temperature was so high, the smell affected his health, and he was very poorly, 3668. It produced sickness and unpleasant feelings, causing him to vomit, 3683.

### Captain MICHAEL WILLIAMS.

Captain of the "Goliath" dredger.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Is stationed in Long Reach, where he has been for a year and a half. Prior to that was in Erith Reach, 3713–15. Is employed dredging for ballast, and gets good gravel now, but at times finds a good deal of "soil," particularly in the neighbourhood of the "Cornwall" training ship off Purfleet. The mud there is eight to twelve inches deep, 3716–24. When he finds the mud dirty he shifts his position to get more into the stream and avoid the sewage deposit, 3725–36. In Erith Reach there is a deposit of nearly two feet of sewage matter, which is sometimes very offensive, 3737. In Long Reach they are obliged to keep out in the stream to get clean ballast, 3738. Since he began to dredge, the mud and stuff on the banks has increased, and when stirred up it is hardly endurable, the smell is so bad, 3739–53. The "Goliath" is about 30 horse-power, and raises, on an average, 3,000 tons of ballast a week when working. The amount raised, however, depends on the demand, 3754–64, 3768. If there is a great demand for ballast, as much as 5,000 tons to 6,000 tons have been raised, 3774–5. There are several other dredging machines at work in Long Reach, which probably do the same amount of work as the "Goliath," 3769–73. Certain restrictions are imposed by the Conservancy as to the distance the dredgers must keep from the shore, because it is supposed that dredging damages the embankments. At present they are not allowed to go within 900 feet of the banks, 3776–82.

### Captain JOSEPH RICHARD WHITEHORN.

Captain of the "Hercules" dredger.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Has been on the "Hercules" 27 years, which is dredging for gravel now between Greenhithe and Purfleet. Before that, used to dredge in Erith Reach. They were stationed there for 10 years, but had to leave on account of the gravel becoming so mixed with "sewage matter" that the lightermen would not take it. It is obliged to be clean, as it is used for

## Captain JOSEPH RICHARD WHITEHORN—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

making concrete, 3783–93. Has tested the gravel by the smell and colour, which was very black. It was quite different to mud, and smelt of sewage. It was also mixed with sand, 3794–3801. Used to work opposite the sewer, in Halfway Reach, at one time, and only came to Long Reach about six months ago, 3802–5. Is in the service of the Trinity House, 3806. Before the outfalls were opened they dredged in Barking Reach, and got very clean, but rather fine, sand. There was no mud with it. Had to leave there 12 or 14 years ago, but they keep shifting up and down to try and find good gravel, 3807–13. The exact place where they now are is on the south shore off Little Powder-monkey Creek, where there is a good bit of ground for dredging purposes, 3814–15. Cannot get good clean gravel above Erith now. They tried at Dagenham two years ago, and only got very soft stuff of a bluish colour, all mud and sewage, which smelt nasty, 3816–22. It was just off the outfall, 3828–30. The Thames Conservancy settles the dredging stations. They cannot go where they like, 3832–3. Dredged a large quantity of stuff away in Halfway Reach. They average about 2,000 tons a week, 3834–7. The Dagenham Shoal, which has been dredged away, contracted the channel and depth of the water. In 10 years the depth of water was increased from 16 feet to 28 feet by the dredging, and mud began to accumulate, 3838–52. The spit of land at Coldharbour Point was dredged away, and the result was that the channel on the north side of the river was greatly deepened and widened. Wherever gravel is clean, the dredging machines go, rather than to shoals, 3853–71. In Long Reach they get clean red gravel, with some sand in it on the north and south shores. They are not allowed to work in the channels on account of the large ships coming up and down, which would be impeded by them, 3882–4. Has not found any sewage matter or mud in Long Reach with the dredger below Purfleet, 3885–91. Wherever there is an eddy-tide there is always a settlement of mud, and has seen it on the shore below Purfleet, 3892–4.

Offensive Odours.—When the sewage matter is discharged from the outfalls it comes out quite as black as ink; and on a summer morning the smell is "faint," and has driven him from the deck, and he has had to remain below. The "muck" with the sand has a similar smell, and can be detected immediately, 3822–7.

## Captain WALTER SHEPHERD.

Captain of the Steam Tug "Wildfire," belonging to the East and West India Dock Company.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has known the river over 40 years, and since the outfalls were opened it has been in a very bad state, owing to a lot of refuse from the sewers floating about, which "smells odious," 3895–3900. Has often seen lumps of sewage floating about, but not lately, 3927–9. Is engaged daily in towing barges down to near Erith, and finds plenty of refuse in the water there, which throws off a bad smell, and is noticeable all the year round, 3938–55.

Offensive Odours.—There is a regular stink from the river, which is worse in hot weather than in cold, 3900–4. From Blackwall down to Erith the smell can be detected, and it is worse at some times of the year than at others, 3949–58.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The mud on the banks of the river is black and greasy, with a bad smell of sewage. The deposit has increased in Halfway Reach, as there is not so much water there as before the opening of the outfalls. The deposit is sewage, without doubt, as, when picking up the anchor, it is covered with it, 3917–26.

Injury to Fish.—Has seen eels floating dead on the water at certain times of the year. They come down with the land water, and on reaching Crossness are smothered by the sewage, 3930–3.

Effect upon Health in the Neighbourhood of the Main Outfalls.—The smell from the sewage at Crossness has not affected his health in any way, but at times has felt sick from it, 3916.

## Captain WALTER SHEPHERD—*continued.*

Set of the Tide.—The sewage would go down on an ebb tide as far as the lower part of the Hope, and would return on the flood to Crossness or further. The ebb tide runs down for seven hours, and is stronger than the flood, 3905–13. Has drifted down with barges on the ebb, but has not made any observations or experiments to test the strength of the ebb and flood, 3934–7, 3915. Cannot with any degree of certainty speak as to the extent of the drift of the tide, as he is more in the habit of making short trips than long ones, 3959–61.

## Mr. AUGUSTUS ROBERT EDMUNDS, Blackheath. Barge Builder.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has known the river for 50 years, and since the outfalls were opened the upper reaches from London Bridge to Limehouse have become purer, and the lower reaches have become more foul year by year, and the smell, more sickening than a closet smell, has increased, 3966–74. The water, when stirred by the steamers, becomes black as ink in colour between Limehouse and Gravesend, 3993–8. The smell of the mud and the water are all bad, especially at the outfalls and at Gravesend, 3999, 4000. Has continually seen slime on the top of the water, which has increased the last year, and his men have picked up lumps of sewage, 4011–13. Goes down to Gravesend four or five times, both on business and for amusement, during the summer, 4014–16.

Offensive Odours.—The bad smell which existed on the upper reaches of the river before the cholera is now to be found in the lower reaches, and is increasing yearly. It is a closet smell, but weaker and more sickening, 3972–4. The smell from the mud in the summer time is exceedingly offensive, especially at Cubitt Town, 3984–6. It is perceptible everywhere in the summer time, 4019.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—His works are at Blackwall Point, East Greenwich, and the mud about there is brown on the top and black below. It is very thick and stinks. About the piers the deposit is the same, but it improves as you go higher, 3979–83, 3987–8. Thirty years ago the mud between London Bridge and Limehouse was the same as it is now lower down, while below it was lighter in colour. Thinks the brown coating is due to the action of the atmosphere, but, not being a chemist, can give no reason for it, 4021–6.

Effect upon Health in the Neighbourhood of the Main Outfalls.—In summer every morning feels unwell as soon as he reaches the river, and suffers from loss of appetite, and faintness from want of food in consequence of his inability to eat anything until the evening. This happens for weeks together, 3975–8. Thirty years ago some of his workmen were ill from the smells, but has not lost any men through death, 3989–92.

Set of the Tide.—When serving his time as a lighterman, has gone down drifting on the ebb tide from Crossness to Gravesend, and come up on the flood to almost the same point. Concludes therefore that the sewage would drift to the same extent, 4001–10.

## Mr. GEORGE SAUNDERS, Erith.

Foreman to Messrs. Beadle Brothers.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has lived near the Thames for 21 years, and been in Messrs. Beadel Brothers, employ for that time, 16 years of which he has been foreman, 4029–31. His duties are to work on the wharf and about it. Most of his time is spent alongside the river, 4032–3. There is a great difference in the river now to what it was before the outfalls were opened The water is much thicker and more dirty, and there is a great accumulation of "sewage stuff" in the berths where the ships come, and they have great difficulty in keeping them clean. Can tell that this accumulation is sewage by the nasty smell, 4034–9. One of their barges sank in the river two years ago, and when raised she was in a "fearful state," having a lot of sewage mud in her, 4040–3. She was under water only two days, 4051.

## Mr. THOMAS MARSHALL, Erith.

### Wheelwright, and Sexton of Erith.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been sexton of Erith for fourteen years, and has had considerable experience in the condition of people drowned in the river during that time, 4086–91. Remembers the "Princess Alice" disaster, and "had to do" with about thirty bodies. Some were brought ashore the same evening—ten or so—and they were in a very dirty condition. The pockets and clothing were one mass of mud (filth it looked like), sewage by the smell, 4092–100. For a week bodies were brought ashore daily, and they were in a very much worse condition, the smell being greater the longer they remained in the water. The smell was very horrible, "almost as bad as a bad privy," 4101–05. Fourteen years ago bodies were not in such a foul condition, nor so full of muck and mess as they are now, 4106–08. Bodies drowned in other waters have nothing the matter with them more than an ordinary corpse, no sewage deposit on them. The state of a body depends on the condition of the water from which it is taken, 4109–14.

Offensive Odours.—The accumulation of sewage mud on the berths has a very nasty smell, especially in the summer. It is like the smell from the discharge of the sewers, 4037–8, 4067–8. Has never noticed any smell coming from the Erith sewage, which is discharged about one hundred yards from the wharf. Only a part of the Erith sewage is discharged there, 4069–80.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—There is a great deal more mud deposited in the berths now than in former years, for where one man was occasionally required to keep the berths clean, he is now regularly employed, and sometimes three or more are called in to assist. The mud is a kind of sewage—black mud, 4048–50.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has had several men laid up during the last few years, more frequently also than formerly. A club to which the men subscribed, and which was self-supporting, now requires help to keep it up, owing to the increased amount of illness amongst the men, 4044–7. The men work in the mud more than they used, but he cannot say that the illness is caused by the smell from the river. Three men are laid up at the present time, 4054–64.

## Mr. RICHARD JOHN NAYLOR, Woolwich.

### Ironmonger and Overseer of the Poor.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has lived at Woolwich 17 years, and has known the river for more than 30 years, 4118–19. The river is in a much worse condition since the outfalls were opened in 1865. When the tide begins to flow a thick muddy substance comes up with it, and the smell in hot weather at times is intolerable, 4120–22. The bodies recovered after the "Princess Alice" disaster were in a filthy, blue-black state, as if they had been black-leaded, and shiny. He attributes this to the action of sewage matter. There were nearly 500 bodies in this state, 4123–7. Has occasionally seen bodies recovered from other rivers, but very seldom. They presented a natural colour, and as a rule were covered with weeds, but in the Thames the clothing was filthy and covered with a slimy matter, 4127*a*–8. The whole of the sewage from North Woolwich is discharged into the Thames. It is collected in a large reservoir, which was constructed by the Metropolitan Board of Works at a cost of 1,500*l*., under Henley Road, North Woolwich, and is discharged at each tide into the river by the opening of a penstock at low water. He believes the northern outfall discharges the sewage within the metropolitan area, which is contrary to the Act of Parliament. The sewer connected with the reservoir is a few yards above the North Woolwich landing pier, 4130–5. Has noticed a good deal of drainage coming out of the sewer, which is opened every 12 hours as the tide suits, by a man who is in the employment of the Woolwich Local Board of Health, 4136–8. A considerable amount of drainage comes out of the sewer, as there are about 250 houses in North Woolwich parish and nearly double that number in East Ham parish at that particular spot, 4139. Was called on, as overseer, to bury the unclaimed dead at the time of the "Princess Alice" disaster. The accident occurred on a Tuesday, and he saw the bodies on the Saturday following. Most of them had been taken out of the river on the Saturday, but some were in the river upwards of a week, which were not identified, 4148–54.

## Mr. RICHARD JOHN NAYLOR—*continued.*

Popular Evidence as to the foul State of the Water in the River near the Main Outfalls—*continued.*

Offensive Odours.—The sewage work at North Woolwich is very offensive and causes a considerable smell, which is augmented by the smell from the northern outfall, and the smell from the sewage deposit on the mud which he has experienced to a considerable extent, having frequently to cross the river on business, 4140–7.

## Mr. JOHN WILLIAM SHOWELL.

### Deputy Harbour Master, and Inspector of Nuisances and Explosives, Greenwich.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—His district lies in the lower part of the river, more particularly from Greenwich to Greenhithe and Long Reach, 4304–5. Has known the river all his life, and remembers the outfalls being opened, 4306–7. There has been a great difference in the state of the river since then. It has become polluted from the sewage; it is a different colour, and much thicker. There is also a great deal of filth and sewage with it, which causes a great smell, 4308–14. There is no discharge into the river from the chemical, gas, or manure works, and if he saw any it would be his duty to take samples. Has however had no occasion to do this during the last few years, 4335–8, 4344–7. In fact the only discharge which he knows of during the six years he has been inspector, has been from the sewers of the Metropolitan Board, 4353–7. Inspected the pipe coming from the gas-works at Beckton only a fortnight ago in the course of his duties, about half ebb tide. Could tell from the colour of the water, and the mud on the shore, whether any offensive matter was being discharged from the pipe. Has never seen anything offensive coming from it, 4358–93. Pure water runs out at low-water, 4397–4401. The pipe is intended to carry off the land drainage water, and there is less water discharged in dry weather than in wet, 4402–4.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—There has been no alteration in the mud up and down the river on the banks, but it is a different colour to what it was before the outfalls were opened. It is black filth, 4315–9. The sewage discharged from Crossness settles about the lower part of Halfway Reach and off mid-channel, and then down Erith Bight. The deposit is like human dung, and it has increased a great deal during the last few years, 4326–31. From Barking there is a great settlement of mud or filth right away down to Dagenham, of just the same description as that from Crossness, 4332–3. In some places when he has let go his anchor he has found eight to ten feet of slime and slush, and has not been able to reach the anchor with his boat-hook. It formerly used to be hard shores, 4341–3.

Set of the Tide.—Anything put into the river at Crossness on a neap tide would drift down to the upper part of Gravesend Reach, and would return on the flood to Tripcock Point, which is above Crossness. The flood is stronger than the ebb, but he has never made any experiments on the tides, 4321–5, 4396.

Injury to Fish.—The sewerage and filth discharged into the river have, in his opinion, killed the fish, 4339–40. Forty years ago he used to have "to do" with the Dutch eel-boats which came up the river, but about 30 years ago they went down to Stoneness Point, on account of the water going bad, 4348–52.

## Mr. WILLIAM EVANS.

### Under-waterman, Woolwich.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—His duty is grappling for things in the river; and when he puts his grapplings overboard the state of the river is such that he can go but very little distance before they are choked, and are no good to him. There is a lot of filth underneath, "sewage sort of stuff which is nothing but slime and "stinking filthy mud." which, when moved, comes up like a lot of oil on the water, and the stench is hardly bearable in summer, 4408–10. Has seen long red worms several inches in length on his grappling ropes.

## Mr. WILLIAM EVANS—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

They are not fish-feeding worms, but eat all the substance of the rope if it is left in many days, and rot it, 4411–14. On a moonlight night, in rowing from Grays Blackshelf up to the outfalls, has arrived there about two hours before high-water, and the discharge from the outfalls has turned his boat aside, 4415. Was fishing for shrimps that night down at Greenhithe, 4423–5

Offensive Odours.—When steamers go up and down the river becomes black as ink, and the stench is very bad indeed in the summer time.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Has seen a boat in trying to anchor in the Government moorings at Woolwich (where the "Fisgard" used to lay) get aground, and the channel is now on the north side of the river instead of on the south as it formerly was.

## Mr. FREDERIC BOWREMAN JESSETT, F.R.C.S.

Medical Officer of Health for the District of Erith.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has lived at Erith between 12 and 13 years. Of late years the condition of the river has been very bad. When first he came to Erith men use to bathe off the end of the pier at high tide in the early morning; but now such a thing would be impossible, owing to the contaminated state of the river from the sewage from the outfalls, which has increased considerably of late years, 4429–33. Last summer, when yachting, on returning with the flood tide, there were large masses of sewage (as large as the table in front of him) floating about, and the ladies were sick and unable to eat owing to the atrocious smell arising from the sewage. He was then off Purfleet. Has often noticed this on the river, especially on the mud at low tide, when the gas can be seen bubbling up constantly, 4460–64.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has had occasion to treat persons for illness which has been chiefly due to the contaminated state of the river. About the middle of last year a man recently appointed to the Thames Police Yacht had not been on board above a week before he was seized with most violent diarrhœa and sickness. He was treated on the yacht for several days, but as he got no better he was removed to the shore, and in two days became better, and very shortly after recovered, 4434–42. A number of men who work at the wharves removing the mud to keep the way clear for the vessels to come up, have come to witness from time to time suffering in the same way as the river policeman. Has attended men from the ballast wharves for the same cause, 4443–6. There has never been any epidemic of this illness, but has had a fair number of cases amongst the workmen on the river banks, 4447–8.

Health of Erith.—That Erith is a healthy place, notwithstanding the state of the river is due to several causes. One is that the place is new, the cottages are nearly all recently built, and in Erith proper the greater number of cottages are drained. Nearly all the wells have been closed, and the Company's water laid on. The soil being gravel adds to the healthiness. There have been several cases of typhoid fever in the town, and they were chiefly in houses near the river, whose wells were found to be polluted with sewage. In some cases the fever occurred in houses which had cesspools, but there has been no typhoid for some few years in the parish of Erith, 4449–50, 4452–4, 4456–68. The Registrar General's Returns for last year showed a lower average for Erith than for London; but it was an exceptionally healthy year, and Erith is a country place, and not a town like London, 4465–7.

Mortality in Erith.—The death-rate of Erith has not been decreasing year by year. In 1878 the number of deaths in Erith was 147. In 1879 and 1880 the number was 165 each year, and in 1881 an exceptionally low rate, viz., 114 deaths. The death rate in 1880 was 14·63 per 1,000, 4475–81. (Makes an annual report, and will hand in his report for 1881 to the Commission, 4471–4, 4482.) The death rate for 1881 was 11·1 per 1,000, 4483. The deaths from typhoid are very few, and there has been a great diminution in all deaths from infectious diseases or typhoid, owing to the improved sanitary arrangements of the place. There has only been one death from diptheria to his knowledge, 4484–7.

## Mr. FREDERIC BOWREMAN JESSETT—*continued.*

Effect on Wells near the River.—A number of wells have been closed every year for the last six or seven years, in consequence of their being polluted with sewage. Has no doubt, but is unable to prove it, that the wells contiguous to the river are tidal wells; that is to say, that at low tide they are empty, and at high tide they are full, so that where the water can run off, the sewage might very easily soak back and contaminate those wells. The water in many of them has been analysed and condemned, 4450–2, 4457. The wells which were closed were principally situated in the High Street. A well in West Street, which was close to a cesspool, was not closed, although the water was twice analysed, and he strongly recommended its being closed, 4488–95. The analyst's reports can be produced if necessary, 4496–7.

Drainage of Erith.—In Erith proper the houses are nearly all drained; but at Abbey Wood, Belvidere, and Northumberland Heath the houses have cesspools, 4453, 4469, 4470.

## Mr. RICHARD ARMITAGE.

Fisherman, Woolwich.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is 66 years of age, and has known the river since he was apprenticed, 50 years ago, 4500. There is a great difference between the river now and what it used to be before the outfalls were opened, 4501, 4502. It is very bad now, and at certain times of the tide the water is quite black and smells very bad indeed, 4509, 4510. There are no worms to be found in the mud now, nor any above the Lower Hope. Any person who says there are "rope-eating" worms higher up is wrong, as he has tried to find them. They were used as bait at one time, and would be glad to find them now, 4525–8. Has occasionally tried grappling and dredging in the mud, but it is no use, for anything which is picked up by the grapnel is all black and slimy, 4534, 4535.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The settlements along the shore are quite black and very slimy. From Dagenham, round Erith, through Erith Bight to Long Reach, there are deposits of mud; but the worst place is at Erith, where the banks of mud rise up seven or eight feet high. They have increased very much indeed of late years, 4511–19. The thickest part of the "deposit stuff" settles along the shore, and nothing can live near it. It has killed all the worms, and if the fish came up they would not live, 4522.

Set of the Tide.—Anything put into the river at Crossness would drift to Gravesend on the ebb tide, but has never practically tested this, 4520–1.

Injury to Fish.—Twenty years ago there were plenty of fish at Woolwich, and has caught them there; but now can get none above Gravesend. Since the southern outfall has been opened they have gone away, and the sewage water would kill them if they came up, 4503–8. Sells the eels he catches at Erith, but has to put them in a corfe to take them there, not into the water, 4531–3.

## Mr. JAMES ADAMS, Grays.

Master of the barge "C. T. F."

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Lives at Grays, on the north shore of the river, and has known the river over 40 years, 4536–9. Since the Crossness outfall was opened the river has become very filthy. Anchors and chains are smothered with filth, and it takes a good deal of time to sluice them with water to remove the muck on them. The smell is dreadful, "enough to knock you backward," 4542–4. At Crossness there is an anchorage for barges, and they lie there for seven hours waiting for the flood. The discharge from the sewers turns the paint all sorts of colours as they lie there. His business is to carry cement in his barge (which is a sailing barge), from Purfleet to the Docks and the Pool, and he goes down the river at all times of the day or night as the tide suits, 4552–3, 4561–3. Can sail over the tide frequently with a fair wind, 4564. A fortnight ago, coming from Beckton, the sewage was being discharged in large quantities as he passed about three o'clock in the afternoon, sufficient to turn the barge away from her helm. For 100 yards all round

## Mr. JAMES ADAMS—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

from the outfall of the sewer the river presented the appearance of being nothing but grease, 4565–73. The river at the northern outfall is in quite as offensive a state as at Crossness. Anchors and chains are covered with the same filth, 4575–84. Has never noticed a sewer pipe coming from the Beckton gas-works, 4585–6

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Years ago, before the outfalls were built, ships drawing 14 to 15 feet of water used to lie just below Crossness, and now there are not five feet of water there, 4540–1.

Set of the Tide.—Sewage discharged at half flood tide would drift up to Blackwall. If discharged on the ebb. it would go down as far as Long Reach below Purfleet, but he is unable to say how far it would return on the flood, 4547–51.

Discharge of Sewage from the Main Outfalls at improper Times.—Has frequently noticed the sewage being discharged from the outfalls at about half flood, or three hours before high water, 4545–6. Has seen it two or three times a week, 4554. A fortnight ago, as he was coming down from Beckton, he saw the sewage being discharged at half flood in large quantities, with sufficient strength to turn a barge from her helm, 4555–9, 4565–7, 4570–3.

## Mr. THOMAS BROWN, Gravesend.

Master of a barge belonging to Messrs. Knight, Bevan and Co.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—For 44 years has been master of a barge running from Northfleet to London, 4589. Remembers the outfalls being made, and since then the river has been in a most filthy state nothing but impure matter. When he heaves up his cable and anchor it is blacker than his clothes. He refers now to Halfway Reach. Erith Reach is just as bad, and the water is as black as ink, 4592–5. The smell when the sewage is being discharged is enough to knock you down, 4596. His barge is a 90-ton sailing barge, and he is in the habit of loading up with coke at Beckton. Has seen a discharge from a sewer pipe at the gas-works which is only water, clear but yellow. The colour he attributes to some process connected with tar, and there is no deposit in the water, 4616–7, 4622, 4640–2. Has not seen this discharge for a fortnight, but often during this summer and last year, 4623–5.

Offensive Odours.—The discharge of water from the Beckton gas-works is not very pleasant, but it is not so bad as the sewers, 4618–21.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Where ships used to lay afloat Halfway Reach in 12 to 13 feet of water, he cannot now float his barge, and there is a great deal of mud on the anchor, 4591, 4611–2. The stuff deposited on the banks of the river is nothing but stinking filthy matter, 4606–7. It is the discharge from the common sewers which causes this matter to be lying at the bottom of the river, 4608–9. There is not much mud in Halfway Reach off Crossness, because below the creek the wall is all stonework, 4610.

Discharge of Sewage from the Main Outfalls at Improper Times.—Has seen the sewage coming out of the Crossness outfall two hours before high water "scores of times." Coming from Beckton the sewage "slews" his barge all on one side, and the water is a body of grease on the surface, while underneath it is quite black, and of a different colour to the other water, 4597–600, 4643–5. The stream of sewage is so strong that the rudder of a barge has to be put over to port so keep her head straight, 4367. "It is not in his power" to complain of this state of things, 4638. Had he only known he would be questioned on these points he would have brought his notes to enable him to give more accurate information as to dates and hours, 4646–8. The difference between high water at London Bridge and the outfall would be from 30 minutes to 40 minutes, 4648. Goes up and down the river continuously, 4649.

Set of the Tide.—Has traced the discharge down as far as below Erith, and has seen it coming down, two or three hours before high water. Has seen very little sewage in Northfleet Hope at the anchorage, 4601–5.

## Mr. ROBERT PLUMB, Gravesend Fisherman.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is 57 years old, and has known the river for 47 years, as he began to work for his father when he was 10 years old, 4651. For the last 14 years the river has been in a bad state, 4666–7.

Injury to Fish.—Fourteen years ago he used to fish in Long Reach for eels, and there were plenty to be caught there. At "dead tides" the eels would be between the two waters, but with the spring tides the bad water would come down, and then they had to take the eels out of the wells to save their lives, 4653–4. Catches fish and shrimps mostly in Sea Reach, but they are obliged to boil them before they arrive at Gravesend as it is impossible to keep them alive now. The foul water kills the fish, 4660–6. Formerly the eel-boats took the fish up in wells at certain times in the day, but now they are packed in boxes at Hole Haven and sent to London in that way. This has been the practice for some years. Has been driven down from Long Reach for 12 or 14 years, 4673–6, 4652.

Set of the Tide.—Believes the ebb tide to be stronger than the flood tide as there is more slack water round the points at flood tide. There is not much difference between the flood and the ebb as to the strength of the tide at the top and the bottom. Has drifted with the tide with a trawl overboard from Gravesend to Leigh Middle, but then there is scarcely any tide at the bottom, 4657–9.

## Mr. GEORGE MARTIN.

Free Waterman. Gravesend.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has known the river for nearly fifty years, and remembers when the out falls were opened, 4679–82. Prior to the opening of the outfalls the water used to be drank in Halfway Reach and at Barking, and it was the custom to fill their water casks there. They have not been able to do this since the outfalls have been in existence, and the river is in a filthy state, being filled up with mud, and slush and muck which "stinks filthy," 4683–8. The colour of the water is as black as a coal, 4692. Has only seen the outfalls opened once when going up and down the river, and that was just about high water. The stench of the sewage was something horrid, 2691–2. Has noticed lately that the water about Greenwich has been very good, which he attributes to the fresh water, but below it is very bad, especially from Halfway Reach to Erith and Purfleet, 4704–6. The water between these places is bad and smells beastly, and can prove it to the Commissioners if they went down there as far as Long Reach, 4717–19.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—On the banks of the river there is a deposit of filthy muck which has quite a filthy stench, and it is much worse than it was a few years ago, 4689–90.

Offensive Odours.—There is a very filthy smell from the river and the deposit of mud on the banks between Halfway Reach and Purfleet as far as Long Reach, 4688, 4689, 4693, 4717–19.

Injury to Fish.—Knows but little about fishing, as he has only been in the habit of carrying fish from Gravesend to Billingsgate. He takes charge of the fishing smacks as waterman, and has been engaged in this work for over 38 years, 4696–9. Has seen fish up the river in corves, which are boats constructed with holes in the bottom on purpose to carry fish, but this was 16 or 17 years ago. Is quite positive that it is not done now, as the fish would not live in the water, 4700–4 The fish for the London market are shipped from the north sea boats into cutters which bring them up the Thames. They are dead, and packed in the hold, 4709–14. Has nothing to do with live fish, 4715–16. Eels only, he believes, will live if brought up in corves at low water by tugs through Halfway Reach, provided also that no sewage is being discharged at the time. They do not feel the effects of the sewage at low water so much as high water, 4720–29.

Set of the Tide.—Sewage if discharged on the ebb at Crossness would drift down to Gravesend Reach, but has never had any opportunity of testing this. He has smelt it as far as Erith and Long Reach, 4693–95.

## Mr. JOHN TALL.

Waterman and Lighterman. Gravesend.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been on the river for 36 years, and there has been a great change for the worse in the river since the outfalls were opened between Erith and Woolwich principally. It is now dirty and filthy, 4732–6. Has seen the sewage discharged from the outfalls a great many times, at all times of the tide, but as he passes up and down six times a week he cannot state any fixed time for the discharge, 4742–4.

Offensive Odours.—The deposits of mud on the shores stinks very much. It has a very nasty smell, 4741, 4748–50.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The mud is thick and black, and you are able to tell when you get into the sewage by the filthy condition of the chain you ride by. It turns it quite black, 4737–40. The mud on the shores is like a "soft slough stuff, more like slime," and it is increasing fast in Halfway Reach, 4745–51.

## Mr. WILLIAM BROWN.

Fisherman. Gravesend.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has known the river for 56 years, and is now master of a small fishing boat, 4754. Since the outfalls were opened there has been a very considerable change for the worse in the state of the river. In the winter seasons fishermen could get a living, but now nothing will breed in the river, 4755–9. Is unable to say what is the matter with the river, as he does not know what goes into it. There is not much difference in the look of it, except in summer, and has not noticed that it has any smell as he has not been above Greenhithe for some time, 4760–6.

## Mr. HENRY EVANS.

Under-waterman and Sand dredger, Woolwich.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has lived at Woolwich all his life, and has been up and down the river two or three times a week ever since he was a boy, 4769, 4773, 4776. Since the opening of the outfalls there has been a vast difference in the state of the river as regards the refuse and rubbish at the bottom, and also as regards the sand that is dredged. At Jenningtree Point, where he used to work every day, thirty years ago, the sand was always good and clear; but of late years it has been very filthy and dark. It is now alternate streaks of sand and streaks of greasy black mud, which is scarcely of any use. In warm weather the men can scarcely work it, on account of the stench and refuse under the sand, 4771–2.

Offensive Odours.—Has perceived a very bad sickly smell from the river, especially from Barking Creek up to the northern outfall. The deposit of mud mixed with the sand smells also very bad, 4772, 4783–4.

Discharge of Sewage from the Main Outfalls at Improper Times.—Has frequently noticed the sewage discharged, from the southern outfall in particular, at two hours before high-water, when rowing down from Woolwich. On the north side there was broken water, and on the south side the sewage made the water smooth. The current from the sewage has turned his boat's head away, 4774–81.

## The Rev. JOHN McALLISTER, Heathfield, Plumstead.

Vicar of St. Nicholas, Plumstead, and Member of the Board of Guardians.

Plumstead Parish and District.—The population of Plumstead is about 15,000, and the northern boundary of the parish extends for two miles along the river. Part of the parish is high ground, stretching from the marshes; and the Government range, which is in the parish, is marshy ground, 4789–92, 4866–69. The marshy ground lies between the railway and the river, and the higher ground slopes up towards Plumstead Common, 4942*a*. His house is half a mile from the marshes, and about three miles as the crow flies from Silvertown, 4942–3, 4945. Has lived in Plumstead for 19 years, 4786–7, and is a member of the Board of Guardians, 4875.

## The Rev. JOHN McALLISTER—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is in the habit of going on the river frequently and by the river, and has paid some attention to the question of how far the Thames has been affected by sewage from an amateur's point of view, 4793–4. Has frequently noticed sewage in the river above and below his parish, but more especially in the part which is co-terminous with the parish, which lies between the two outfalls, 4795–6, 4798. Has seen it floating up and down the river; frequently going up, and at a time when the sluices were shut, as he understands the rule is to open them only when the tide is running towards the sea, 4799–801. Was not aware that there were places of any magnitude on the Thames where the sewage was permitted to flow into the river; for example, Erith; but has seen the matter that discharges from the Beckton Gasworks, and the sewage from Barking Creek, 4900–5. Does not remember the river before the outfalls were opened, 4852.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Has frequently seen deposits on the sides of the river, and has examined them carefully by inspecting the mud. It is evidently human excrement in a state of decomposition, full of worms, 4802–5. Has noticed these large deposits of worms every summer for the last nine or ten years, but his attention was not called to it before that time, 4841–2, 4849–51. In appearance, these worms are red, and vary in size from two to three inches in length to very small. They were to be seen in very large quantities, but he does not draw his inference that the deposit was sewage from the presence of these worms, but from its smell, 4843–8. Has never made any analysis of the mud, nor examined it microscopically, but it differs from mud found in other parts of the river in possessing a very offensive smell, which, so far as his knowledge extends, is inseparable from sewage in a certain state of decomposition, 4851–6. Has noticed a smell in mud taken from the bottom of a pond, but it is different to the smell from the river mud. If he were given a sample of this mud to which he has been referring, and one of pond mud, he believes he would have no difficulty in discriminating between them, 4856–8. The mud which is contaminated by sewage is deposited in little creeks by eddies, and in more open parts the sewage is not deposited, and ordinary mud will be found there. Is unable to point out any particular spot where sewage mud has been deposited, but has noticed and examined it between Crossness and the Arsenal at Woolwich, 4859–65.

Offensive Odours.—The smell from the deposit in a state of decomposition has a very offensive smell, especially in summer, 4807. It is noticeable all over his parish, even at a distance of three or four miles from the river, and he can discriminate between the smell of the chemical factories and the smell from the river as easily as he can detect the difference between the smell of an onion and a boiled cabbage. The sewage smell is quite distinct from the other, 4808–13. The smells are worst when the wind blows from the north-east, from the middle of March to the middle of April, and from the middle of September to the end of October. The smell from the sewage is very strong and very disagreeable, 4814–16, and can be detected any year at the times he has stated all over his parish with a north-east wind, 4895–9, 4917–21. A smell is emitted from the discharge at the Beckton Gasworks and at Barking Creek, but it is not so bad as the smell from the outfalls. His attention, however, has never been specially directed to that part of the river, 4904–16. Has never heard any complaints made of offensive odours proceeding from the chemical works by his parishioners or the inhabitants of Silvertown, 4946–9. Has noticed the sewage smell at East Wickham House, the residence of Mr. Jones, which is more than three miles from the outfall, 4950–1. His attention has been directed to the nuisances evolved from the factories on both sides of the river, and though he has made frequent complaints on the subject, the guardians have taken no particular steps in the matter, nor has the medical officer either. The general impression on the minds of everyone to whom he has spoken is, that it is no use trying to remedy this evil when the nuisance of the Thames is so great. The matter requires to be dealt with as a whole, 4922–31.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has taken particular interest in the question of health as affected by the smell from the

## The Rev. JOHN McALLISTER—*continued.*

### Effect upon Health in the Neighbourhood of the Main Outfalls— *continued.*

sewerage, and has noticed that foul air, when it comes over the parish, produces the same effect on the inhabitants as a hot wind does on vegetable life under certain conditions. The *vis vitæ* sinks directly, and all feel it, himself included. His vitality is not as powerful when under the influence of these smells as it is at other times. Has had scarlet fever in his house three times while living at Plumstead, and has lost two children from it. Though holding an opinion on the subject, he would not like to commit himself positively to the fact that the sewage was the direct cause of the fever 4817–21. The north-east wind, when blowing over marshes in which there was a great deal of sour half-decomposed water, would probably have an injurious effect on the population, but if the marshes were flat lands and well drained they would not have that effect. The Plumstead Marshes are supposed to be well drained, and he knows of nothing of an injurious character that could emanate from them, 4870–3. Has never known of a real case of ague in Plumstead, since he has lived there, 4874–7. The general health of the district, as compared with that of the whole of the metropolis, is not so good as some, though perhaps as good as others, 4878. Has had some cases, though not many, of typhoid fever in his district, 4893. Has noticed in the cases of certain patients, in whom he is interested, who are suffering from depression of *vis vitæ*, that the pharmacopœia of medical men to whom he has taken these patients, generally consists of quinine, and this depression is on the increase, 4932–6. There is no local board of health at Plumstead, but the district board of works take cognizance of sanitary matters. Certain sanitary matters are referred to that board, such as complaints as to sewage, while certain other things are relegated to the board of guardians. There is a medical officer of health for the district, 4937–41.

Mortality of Plumstead.—His general impression is that Plumstead stands lower than most of the other districts, and about equal to some of the worst of them. From memory he cannot state what the death rate per 1,000 is in his district, 4879–83, nor can he say how much of the mortality of the district is attributable to zymotic diseases. Scarlet fever is always present, and he attributes the violent periodical outbreaks at certain seasons of the year very much to the poisoning of the atmosphere. Everything is done to isolate the cases and prevent the spread of the disease, but it is a very difficult matter to deal with. Is not aware that the medical officer has made any special report on the means to be taken to avoid the incidence of these epidemics of scarlet fever, 4884–8.

Effect on Wells near the River.—No report has been made by the medical officer specially on wells in connexion with cesspools, and on the pollution of water from contact with, or in the vicinity of, cesspools, 4891. The water supply of the parish generally is by means of artesian wells, which are supplied with water by the North Kent Waterworks, said to be the best water in the neighbourhood of London. His house is so supplied, and was at the time of the scarlet fever in his house, 4957–60.

Drainage of Plumstead.—The use of cesspools is supposed to have been discontinued long ago. The main drainage runs through the parish, and every house and street within its reach is supposed to be connected with and drained by the main system, 4889–90. The marshes are relieved of stagnant water by a perfect system of drainage. The Government undertake that part which belongs to them, and arrangements have been made to drain the other part by means of sluices, which are opened at certain times, 4961.

Discharge of Sewage from the Main Outfalls at Improper Times.—Has seen the sewage floating up the river at a time when the sluices must have been shut, 4801–32. Has also seen it going up the river on the tide frequently when he himself has been on the river and on the banks. Noticed it last summer in June and July, 4800, 4822–26. He saw greasy matter, conveying to his mind the same impression as a small stream of ketchup poured into brown soup, 4827, 4828. Has seen the outfalls opened and the sewage flowing into the Thames frequently. On these occasions he has been watching the river casually, with no idea that he would be called on to give evidence, 4829–37, 4952–6.

## Mr. HENRY PASSFIELD, Lambeth.

### Fisherman.

Injury to Fish.—Is 45 years of age, and has fished in the river over 30 years, 4963–5. In the first part of the year, up to August, he is in the habit of fishing from Sunbury to Hungerford Bridge, and also fishes lower down, as far as Lower Hope Point. It depends on the time of the year whether he fishes up or down, 4966–75. About five or six years after the outfalls were opened the sewage affected the river, and drove the fish away. Used to catch shrimps at Barking and in Halfway Reach, but what he fished for to get his living was eels, 4976–81. In Limehouse Reach, which is a few miles above the outfalls, no fish are to be caught, 4982–5. Flounders, dace, roach, and eels can be caught at Hungerford Bridge in August and September, but there are no fish at all between that point and Gravesend, 4986–90. Roach and dace being fresh water fish, are never seen below Hungerford, but eels are fresh and salt water fish. The eels caught up the river are a different class to those seen down below, 4991–8. In going to fish down below he puts different gear into the boat and fishes all the way down, 4999–5000. Never tries to catch fish between Hungerford and Gravesend on account of the sewage. Nothing will live there, 5001–6, 5008. Year by year, from five years after the opening of the sewers, the state of the river has become worse, and fishermen had to move down from Erith to Greenhithe, 5007.

## Mr. WILLIAM HENRY LEWIS, King William Street, Greenwich.

### Port Sanitary Inspector to the Port of London.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—The extent of the jurisdiction of the Port of London Sanitary Authority is from Teddington Lock down to the north-east corner of the Isle of Grain, and there are two other inspectors who share with him the charge of the district, 5011–11*b*. Has been engaged on this duty since 1873, the date of the formation of the authority, and is chiefly engaged between Greenhithe or Erith to Battersea. At times he is at the extremes of the district, 5012–14. His duty takes him on some part of the river every day, and since 1873 has noticed a most decided change in the river, 5015–17. During the summer of 1880, the river from Jenningtree Point to Cherry Garden Pier was in a very bad state. Black patches of stinking matter, which seemed to have been drawn up from the bottom by the heat, floated on the surface of the river, and when touched broke up. The size varied from six to eight feet in length by six feet in breadth to half that size. There was a very offensive smell with it, and this foul state of the river lasted through July to about the middle of August, when it was dispersed by a heavy rain, and was not seen again, 5018–28, 5040. In 1858 the river presented a similar appearance, 5029. Witness was at that time connected with the Dreadnought Seamen's Hospital, which was moored then off Greenwich, 5030–1. There was a greater amount of this foul stuff, and it lasted for a longer time. The patches extended over the whole width of the river, which was in fact a black ditch from Greenwich up to London, 5032–9. After 1864 the river seemed pretty good, but during the last six or eight years it has assumed rather a bad character, and has been getting gradually worse; blacker and smells badly, 5041–4. In July this year it began to be rather bad, but not so bad as it was in 1880, 5045–6. In 1880, when with Dr. Collingridge, the medical officer, he took samples of the water at the following places:—Jenningtree Point, Purfleet, by the "Cornwall," and at Charlton inside the "Warspite." They were taken on the flood, and the samples smelt like sewage, not like pure water, 5058–65. On the 30th June 1882, in company with Dr. Collingridge, he took some more samples. No. 1 was taken at 2.25 p.m., about half-an-hour after high-water, a few yards up Barking Creek. No. 2 was taken at 2.30 p.m. at Lawes' Chemical Works. No. 3 was taken at 2.35 p.m. at Barking, about 200 yards below the outfall, in a line with the sewage. No. 4 was taken at 2.50, at Halfway House Point on the south shore, about 30 feet from the bank off the surface. No. 5 was taken about 50 yards above the Crossness Outfall, at 2.55 p.m. No. 6 was taken at Crossness, over the line of sewage discharging from the outfall, at 2.59. No. 7 came from off the second jetty at

## Mr. WILLIAM HENRY LEWIS—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

Crossness Pumping Station, about 120 feet off the quay, at 2.59. No. 8 was taken at the West Kent Tanks, from the upper and middle reservoirs (about half from each), at 3.55 p.m. No. 9 was taken at Greenhithe, at 5.40, in a line with the causeway, close in shore. No. 10 was taken at Barking, at 7.10 p.m., at the sewer at low-water, the outfall running with great force; and No. 11 was taken from the bottom, close in shore, at 7.15, about 150 feet below the outfall, 5066–93. Except No. 4, these samples were taken below the surface, 5081. On the 28th July, 1882, between midday to 10 o'clock on the 29th July, he took 24 samples of water, which were submitted to Dr. Tidy. The place from which they were taken was about the same spot, viz., off Crossness Pumping Station. The depths varied from 3 feet below the surface to 18 feet below, when the sewers were discharging. There was a very great stink from the outfall all night. No. 1 was taken at 12 noon, near the upper outfall, about 3 feet below the surface, and 60 to 70 feet off the quay. Sewer running. No. 2 taken at 1 p.m., same place. No. 3 was taken at 2 p.m. from the bottom, 18 feet below the surface, near the upper outfall. No. 4 at same place at 3 p.m., when he came in contact with the wooden sewer. Water discoloured and warm. Sewer still running. Upper outfall stopped running at 4 p.m. till 11.20 p.m. when it began again, and stopped 3.30 a.m. At 2 a.m. the bottle caught in the outfall, and it was 15 minutes before it got clear. At 8.15 a.m. noticed the sewage returning on the flood, and traced it from the powder works up to the point at Crossness, and then over to Bridge's Powder Magazine, 5097–125. Has also taken samples of mud when the tide was on the turn, and noticed sewage then coming up. The three outfalls were running with great force, 5126–35. The mud samples were taken from opposite the clock, next the pumping station at Crossness, from near the upper outfall in a line with the jetty, and from between the Government Powder Magazine and the powder jetty, 5136–7. There are in his district a considerable number of outfalls discharging into the river quite distinct from the outfalls of the Metropolitan Board of Works, from which sewage flows. In Barking Creek there are one or two small affairs, but when passing up the creek you would not observe at any time any soil floating about it, 5149–53. The discharge from Beckton sewer is sometimes offensive. The size of the outfall is 18 inches in breadth by about 23 inches in length, and is oval-shaped, 5156–9. The largest outfall is at West Ham, which is, however, a small affair, and can only be seen at dead low-water. All the rest are "privies," 5160–4. It is part of his duty to make returns and report upon foul outfalls at stated times, and when ordered to do so by the medical officer, 5165. Roughly speaking there are at least 40 privies or closets at Poplar, and eight or ten at Limehouse, 5166–8. By a return he made, which is embodied in the Report of the Port of London Sanitary Authority, dated 15th December 1881, there were 187 foul outfalls on the north side of the river, and 182 on the south side of the river, 5169–74. Of these 117 on the north and 59 on the south, are said to be within the jurisdiction of the Metropolitan Board of Works, and in his return privies and closets are included under the head of outfalls. It does not mean sewers only. Rotherhithe, for instance, has 19 outfalls, which would, with one exception be closets for riverside houses, 5178–86. In Bow Creek there is a Metropolitan Board of Works sewer from which he has seen foul stuff coming out. Believes it to be a storm outfall, 5188–93. In Barking Creek there is only one sewer to his knowledge, but he has seldom seen it, 5195–8. Has continually taken samples of water and mud for many years, and has sent them to different gentlemen for analysis, 5192–201. Attributes the foul state of the river to general dryness of the year, and to the heat and drought in July, 5202–5.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—On the 28th June he took three samples of mud from the bottom of the river, 60 feet from the shore, and from 600 to 700 yards above the southern outfall, 5138–48.

Effect upon Health in the Neighbourhood of the Main Outfalls.—While out on the river on the 28th June taking samples, the fearful stink from the mud-

## Mr. WILLIAM HENRY LEWIS—*continued.*

Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

bank near the outfall knocked up the boy who was in the boat, and he was ill for a day or two after it, 5119. The health of the sea-faring population on the river is generally good, and there is no epidemic of disease amongst them at present. Is rather proud of the healthiness of the Port of London as compared with other ports, 5174–7.

Discharge of Sewage from the Main Outfalls at Improper Times.—Has traced sewage in the river up to the lower part of Blackwall Reach frequently, and has seen it flowing up stream. The track can be seen distinctly as coming from Barking or Crossness outfalls, and he is able to distinguish that it comes from there, 5048–57.

Discharge from the Storm Overflow Outlets.—Is conversant with most of the storm overflow outlets, and has seen them discharging frequently both in rainy and dry seasons during summer time, at Blackfriars and at Deptford. Has noticed an offensive smell at those times from the river, and in the Broadway at Deptford. By the smell you can tell whether there is a discharge from the outlets without going on to the river to see, 5208–12.

## Captain JAN VISSER, Harlengen, Friesland.

Captain of a Dutch Eel Vessel.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is 51 years of age, and has been engaged in the Dutch eel trade since 1858. In the spring of the year he used to come up to Erith until March or April when they had to go lower down the river on account of the bad state of the water, 5213–22. In 1866 and 1868 the river had become much worse, and he found it necessary to lay in Hole Haven Creek, as they do now, both in spring and summer on account of the bad condition of the water, 5223–9. Twenty-four years ago the foul water was up at London, 5256.

Injury to Fish.—Eels could not live now in the river below Woolwich, because between Woolwich and Erith the river is foulest, 5230. Eels are brought up to London from Hole Haven in boxes in the watermen's boats. It is not possible to bring them up in the eel boats at any time of the year as they would not live through the foul water, 5231–3, 5239. The value of a cargo of eels varies according to the state of the market from 500*l.* to 800*l.* One boat carries 10 tons, 5234–8. In 1864 the eels had to be shifted during hot weather at Gravesend into boxes for carriage to London, 5242–5. In the early spring, or in the latter part of the year after much rain, eels are sometimes taken in the wells to Billingsgate, because the water is purer after continuous rain. He only brings part of his cargo up in the winter at a time, on account of the market being slack, and sells part to people who come on board to buy it, 5246–51, 5261–5. In the summer time when the water is bad the whole cargo is brought up in boxes, as was the custom in 1858. When they laid off Erith the eels were brought up in pots, 5252–5. If a cargo is brought up in the hold of a boat it is always towed up by a tug, as it then passes rapidly through the water. To go slowly between Barking and Woolwich the cargo would be killed by the water, as all the eels brought from Holland are alive, 5257–60.

## Mr. HENRY SPADACCINI.

Inspector to the Port of London Sanitary Authority.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Was formerly a mate in the General Steam Navigation Company's ships, and has been at sea over 15 years sailing from London, when he had a good opportunity of observing the state of the river, 5266–71. During the last ten years has noticed the river to be in a very foul state, and has heard many remarks passed on it by passengers in the ships he was in, 5273–4. On the 28th July to the 29th July he took 24 samples from the river at Barking, one every hour from noon on the 28th to 11 a.m. on the 29th July, 5275–6. High water at Barking was about noon. The position he took was right in the

## Mr. HENRY SPADACCINI—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

flow of the sewage, 5277–81. The first sample was taken on the first of the ebb when the sewage was running out strongly. A barque moored off the outfall did not swing to the ebb until the sewage had been running for a quarter of an hour. The sewage began to run out before 12 noon. The smell was so bad he had to remove his boat to some distance. It made him feel sick. Could tell when the sewage began to run out by the difference in the water and by the smell. The water becomes quite blue-black in colour, 5282–94, 5296–7. At three o'clock the sewage was running out so slowly as not to be perceptible on the surface as the sewage runs out under water. The arches were beginning to be uncovered, 5295, 5298, 5299. At four o'clock the arches were uncovered three feet, and the sewage was running out at the rate of one knot per hour. The sewage at this time was "pure, undiluted" sewage. The boat was on the sill, and the sample was taken from the sewage as it poured out, 5300–4. At five o'clock there were seven inches of sewage on the sill which was between 65 and 70 feet wide, 5305–6. At six o'clock there were five inches of sewage flowing from arches Nos. 1, 2, 8, and 9, at the rate of one knot per hour, and from the other five arches at half a knot per hour, 5307. At 6.45 p.m. the barque swung to the flood tide, 5308–9. At 8 p.m. he noticed large patches of sewage deposit become detached from the river bank and float up the river with the flood tide, 5311–2. At 9 p.m. he noticed a strong sewage smell, but is unable to say whether the sewage was still being discharged, 5313–4. Past midnight, at nearly high water, there was no doubt that the sewage was being discharged, both from the smell, and also from the ripple on the surface of the water, and that it was running up the river, judging from the position of the barque as she swung at her moorings, 5315–8. At 7 a.m. the barges in the offing swung athwart the river, there being no tide there at dead low water. Sewage was running out over the sill at the rate of one knot per hour, 5319–22. There was no rain at all on this day during the whole time he was taking samples. There was a slight fog at night, 5323–5. The samples he took were handed over to the Port Sanitary Authority at the office in Greenwich, and were the first he ever took. Has taken samples since, records of which can be produced if necessary. The arches are covered as early as the second hour of the flood, as the tide rises very quickly, 5334–48. The barges swung to the flood at 7.35 at which time the sewage was running out over the sill at the rate of one knot per hour, 5349–50. Hands in notes of his samples, 5276.

Discharge of Sewage from the Main Outfalls at Improper Times.—At 7 p.m. the sewage was flowing from the end arches and mixing with the water of the flood-tide, and all the time he saw the sewage coming out he heard a noise in the arches which continued after he ceased to see the sewage flow. From this he inferred that the sewage was still flowing, 5019. The sewage began to be discharged on both occasions during the 24 hours he was stationed at the outfall before the tide began to go down, and naturally the sewage flowed up with the stream, 5329–32, 5315–18.

## Captain RICHARD MARSDEN.

Harbour Master for the District of Gravesend.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been harbour master at Gravesend for one year, and prior to that he had the Limehouse district, when he was able to make some notes and observations on the state of the river, which he now hands in, 3551–6. In 1879, when passing the southern outfall, he found the water very filthy, with a horrible smell. In 1880 (February) the water was very bad, accompanied by a most offensive and sickening smell. On the 24th July 1880, at three-quarters flood, the water was very foul off Cubitt Town, the stench and state of the river being very bad, with a black slimy appearance on the water. He never saw the river in a worse state than this, 5377–84. On 1st September 1880, at a quarter ebb, off the northern outfall, the water all the way down Barking Reach was in a very bad, black state, and stinking horribly. On the 2nd September he again observed a very foul stinking fluid coming out of the same outfall. On the 8th the

## Captain RICHARD MARSDEN—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

river was very bad in Halfway Reach right up to Blackwall, the water being black, and the smell sickening. Two days later the water was bad down to Erith, 5386–90. On the 29th September the river was charged with sewage, the worst coming from the northern outfall, 5391. On the 2nd September 1881 the water was much discoloured at the sewage outlets, and on the 5th September the water was very foul and stinking from the northern outfall down to Erith. Has seen the water much cleaner at times when the sewage is being discharged than at others, 5395–401.

Offensive Odours.—On each occasion when he has found the water in a foul state it has been accompanied by a most offensive sickening smell, 5380–97. The smell noticeable at Blackwall and Erith is the same as is to be found at the outfalls, only fainter, 5414.

Effect upon Health in the Neighbourhood of the Main Outfalls.—The fishermen and others whose daily occupation is on the river are, as a rule, a pretty healthy set of men, and are not affected by any disease or illness consequent on their working so much on the water, 5410–13. Knows of none of the men in his employ who have had to give up their work on account of sickness, 5415–17.

Discharge from the Storm Overflow Outlets.—On the 24th June 1879 he noticed a large quantity of sewage coming into the river from the Ratcliff Cross outfall on the ebb-tide. Has frequently seen a similar discharge whenever there has been rain. The size of the outlet is 4 feet broad by 2 feet deep, 5357–60. On the 26th June, at 11.30 a.m., on three-quarter ebb-tide, he encountered a great quantity of sewage matter of the worst possible kind issuing from the Ratcliff Cross outlet, and he reported the fact to the Thames Conservancy Board. It could not have been worse if he had been in the sewer itself. Being just before low water the excrement would be carried up by the flood-tide and deposited in the higher reaches of the river. There had been some rain on that day, but not heavy rain. The sanitary inspector was on the river at the time and took samples, 5361–75. On the 26th October a large quantity of sewage was discharged from the same outlet on half ebb-tide, It was rainy weather on that occasion, 5392–402.

Injury to Fish.—Fishermen used to trawl for shrimps in Long Reach, and in Erith Rands good fish used to be caught, but now the bottom is so muddy, and the water so foul, nothing is found there. The eel scoots cannot lie in the river above Hole Haven, and when they are towed up to London the valves in the boats are shut to prevent the impure water getting to the fish. The shrimping boats are now fitted with boilers to boil the shrimps on board, as they are not able to bring them up to Gravesend alive in the wells of the boats, 5356.

## Mr. GEORGE ROBERT SHOWELL.

Master of the Steam Launch "Hygeia," belonging to the Port of London Sanitary Authority.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Was born and brought up alongside of the river, and has been on it for 27 years, 5418–22. Has often noticed a foulness in the condition of the river, which is worst at low water round the bight of East Greenwich. It is what he would term sewage. Has seen it at Woolwich on low water, on the young flood, and especially on high water, and all round that neighbourhood, 5423–31. Has seen the sewage stop in Halfway Reach and hang on to the eddy at the points, 5432. Has anchored frequently off the outfalls and seen the sewage discharged. It is noticeable by the colour of the water. At times, with an easterly wind, or in calm weather, it has not flowed away, 5433–8. When he has hauled in his anchor it has been covered with sewage, and the chain has had to be washed by the sailors as it came through the hawse-hole, 5457–9. The east wind and eddy tides combined have stopped the sewage from flowing away. They stop the tide also, 5460–2. Has seen the sewage at East Greenwich several times this summer on low water, 5463–8. Has had unpleasant tastes and smells from the spray of the water when he has been coming through Halfway Reach head to wind, 5477–81.

## Mr. GEORGE ROBERT SHOWELL—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Formerly there used to be 14 feet of water above the Powder House by Crossness, but now it is all mud intermixed with sewage, of a bluishblack colour, and smells badly. Has seen vessels aground there, 5450–6.

Injury to Fish.—Twenty years ago the condition of the water at East Greenwich was very good, and all sorts of fish were to be had there, amongst them fresh-water haddocks, 5470–2.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Is a good deal on the water, and has been all his life, and, generally speaking, he enjoys very good health. Has never experienced sickness or faintness from the condition of the river, 5473–8.

Discharge of Sewage from the Main Outfalls at Improper Times.—Has seen the sewage discharged two hours before high water, and continuing until three-quarters ebb. On the 16th November 1882, when with Dr. Collingridge, at 12.15 p.m., the sewage was running fast out of four pipes at Barking. It was high water at London Bridge about 5 p.m., and the tide was flowing up then, 5437-49.

## Captain JOHN FITZGERALD, R.N.

Harbour Master of the Central Station on the River Thames.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is a Staff Commander in the Navy, and his district as Harbour Master extends from Greenwich to Greenhithe. Has held his position for five years, and has had almost daily opportunities of observing the river, 5482–6. There has been a change for the worse during that time, especially in 1880 and 1881. The water has become very much worse, and it is, in his opinion, due to the outfalls at Barking and Crossness. At present it is comparatively clear, 5487–91. Has kept a journal daily, and entered in it particulars as to the state of the river. In 1880 he took special observation, as it was in a worse state than it had been before. He also took special notes in 1881, 5492–6. On the 24th June 1880 the stream on the flood and ebb was apparently charged with sewage, and the smell from the river most offensive. On the next day, between Charlton and Erith, the smell from the sewage pervaded the river, being quite as strong on the flood as on the ebb. On the 26th June the smell was still offensive, though not so bad. On the 6th and 7th July the smell was very bad in Erith and Halfway Reaches, the water being comparatively clear on the 6th, but much discoloured on the 7th. On the 9th the water was much discoloured, and smelt badly all over his district. On the 11th the water above Woolwich was strongly impregnated with sewage, 5498–5509. On the 12th July he landed at the southern outfall at half-flood to complain of the state of the river, and was told the sluices had only been opened at the proper time. But as the upper part of the river was foul, and below the outfalls it was clear, he doubted the statement, 5510–1. The same condition existed until the 17th July, when the river was in a worse condition than he had ever known it from Woolwich to Erith. From side to side it was heavily charged with sewage, and the stench almost unbearable. On the 18th it was black with sewage, but it got clearer next day on the surface, but bad inshore. On the 21st the surface was clear, but filthy and stinking underneath; the steamers passing stirred it up, and at Leatherbottle Point the water was nearly black at the last quarter flood for a mile, 5512-21. On the 22nd July the river was in a filthy condition from Charlton to Erith, and the sewage was apparently working its way up. He could see it. It continued in this state, and on the 26th July at low water the river was choke full of sewage from "Bugsby" down. Stench abominable. Same on the flood. As the tide fell the water got "thicker," or had more suspended matter in it. On the 27th the water was tolerably clear at high water, but big black patches varying in size were visible at first quarter ebb. He fancied these patches were due to the clean water being swept away from the surface, 5522–36. His opinion is that these patches were sewage, 5537–9. From the 28th July the river got clearer in places, and the smell gradually diminished (but the foreshore and landing-places were clothed with sewage mud) until the 5th August, when it was fairly clean and free from smell, and, with a few exceptions when the foul state

## Captain JOHN FITZGERALD, R.N.—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

and smell were noticed, it continued to remain clean. At the end of August he went on leave, and the observations were continued by the officer who relieved him. The cause of his taking all these observations was simply the excessively foul state of the river, and he felt it to be his duty to notice it, and report the facts to the Conservators. The weather was hot and sultry, 5556–7. In October he noted that the river was charged heavily with sewage, especially in Erith and Halfway Reaches, and air bubbles were visible right across the river, 5558. From October to the following July the river was not so bad as it was in the summer owing to the cool weather, and the fresh water coming down, 5562–5. In July and August 1881 the river became very foul and offensive; it was nearly as bad as in 1880. He took notes of the state of the water, which correspond almost entirely with those taken in 1880. The weather was hot, 5559–61, 5556–85. On the 19th August, at 2¾ hours before high water (at 6.40 p.m.), the northern outfall was flowing into the river, and a sample was taken by two of his watermen. High water was at 9.25 p.m. on that day, 5586–8. In 1882 he took some notes of the state of the river. On the 17th March, at the last quarter ebb, the river in Halfway Reach and off Erith was in a very foul state and smelling badly. On the 30th June the water off Charlton was very offensive, and smelt strongly of sewage at two hours flood; on the 10th August the water at last quarter ebb in Halfway Reach was very turbid and full of air bubbles, giving off offensive odours; and on the 28th August the river in Halfway Reach, and off Erith, was very much discoloured and smelt badly, 5598–5604. During September he was away on leave, but on the 26th October the water in Barking Reach was heavily charged with sewage and smelling badly, 5604–5. He began to take notes of the river in 1878, but confined them principally to the summer months. The river has not been so foul in 1882 as in former years, which is due to westerly and south-westerly winds accompanied by a good deal of rain. The foulness is due to the discharge of sewage from Barking and Crossness outfalls, 5606–12. Believes he commenced making entries in his journal in 1877, soon after he took up his duties as harbour master. Quotes extracts from his journal of December 1878 up to June 1880 as to the state of the river, which he made on board the "Conservator" at her moorings off Charlton, 5638–50. There are very few entries as to the clear state of the river, owing to its seldom being in a state to justify him calling it so, 5651–5. The expression "charged with sewage" which he has frequently made use of means that the water was full of sewage from its containing a lot of suspended matter in it, 5656–7. The cause of his watching the outfalls in 1881 was to ascertain the reason why the river was in such a filthy state. During the night tides he sent two men to watch, and he went in the daytime, 5663–4. At times the water would be clear on the surface, but directly a steamer passed the screw would stir up the lower part, and it would be found to be in a filthy stinking condition. He has seen this in all parts of the river, except in Long Reach, within his district, 5665–71. The sewage during the worst part of the seasons of 1880 and 1881 filled the river, and gradually extended upwards as the seasons advanced until it reached Greenwich. Now it is very much better than it was three years ago, 5672–7. Speaking generally, there is nothing offensive in the river at present, but it has been very bad this year (1882) on days when he has not recorded the fact, 5678–81. Has steamed and rowed through the black patches on the river, but has never examined or analysed them. Has taken the temperature of the clear water and of the sewage, and has found that there is a difference of eight or nine degrees between them. He recorded those observations, 5682–9. The samples taken at the outfalls in 1881 were handed over to the Conservators for analysis. The men reported verbally to him the state of the river, &c., although they made notes at the time, 5690–6. The patches on the river were from the smell composed of sewage, 5697–9.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—In 1878, on the 18th December, he personally took observations on the depth of the mud at various places in the river between Woolwich and Erith. The depth ranged from 5 feet to 15 feet. (*The paper containing the details was handed in, and will be found*

## Captain JOHN FITZGERALD, R.N.—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

*after Q.* 5615 *in the printed evidence.*) On the 20th November 1882 the steamship "Fatfield" was in collision, and was run ashore in Barking Reach on the Essex side above the "Farmer's teeth" and embedded herself in 12 feet of mud, 5615, 5623-5. He saw the ship in the mud, which was black stinking sewage mud, 5625-6. The conclusion he drew from these observations was that the mud was increasing in the river, 5616-7. His opinion was that the mud was composed mostly of sewage. (*This was objected to by Mr. Bidder, as no analysis was made by witness.*) He is familiar with Thames mud. The mud he sounded varied in character. In some places it was black stinking mud, and not so bad in others. Samples were taken at these places from time to time, and were analysed by competent men, 5622. The observations handed in were taken in 1878 for the purpose of the Mud Inquiry, at which he gave evidence. The cause of the mud banks he takes for granted in consequence of what he sees, 5627-37. In going up and down the river he has probed the depth of the mud at different places in addition to the observations taken in 1878, and although he has not recorded the results he has formed in his mind an opinion as to the state and condition of his district generally. His inference that the accumulations of mud were due to sewage was drawn from his subsequent observations, and not from the experiments made in December 1878. He compared the 1878 soundings and the depth of the water with the surveys taken previously, and he drew his inference from that also. The increase is going on, and he attributes it, not wholly and solely, but mostly, to the contribution of sewage, 5700-13.

Offensive Odours.—During the summer months of 1880 and 1881 the river was in a very foul state and the smell from it was abominable. The smell pervaded the air from Charlton to Erith. At times it was almost unbearable. One of his men was sick from the smell. The smell was very bad for 23 days in 1880, for 16 days in 1881, and on a few occasions in 1882, 5497-605. On the 10th August 1882 the smell was very unpleasant, 5658-62.

Discharge of Sewage from the Main Outfalls at improper Times.—On the 12th July 1880 he landed at the southern outfall to complain of the state of the river. He was told the sluices had been opened at the proper time, but he doubted that, as, the tide being half flood at time, the river below the outfall was comparatively clear and the air free from sewage taint, while in Barking Reach it was the reverse, 5510-1. On the 19th August 1881, at 2¾ hours before high water, sewage from the northern outfall was observed to be flowing into the river, a sample of which was obtained in front of the works by two of his watermen. High water would be above 9.25 p.m. on that evening, 5586-88. On the 20th, 21st, and 23rd August sewage was seen issuing from the northern outfall on the half flood tide by the same two men, 5589-93.

## Captain CHARLES HENRY JAMES.

Harbour Master of the Thames Conservancy at Greenwich.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has known the river all his life, and is now 69 years of age, 5714-6. Has been harbour master at various points of the river since 1840. For 11 years his district was from Gravesend to Woolwich. In 1850 or 1851 he came to Limehouse district, which extends from Limehouse to London Bridge, 5722-5, 5730, 5734-5. Is now harbour master at Greenwich, 5727. In 1828 he went to sea, and at that time people used to drink the Thames water and take it to sea with them. It was taken from a hulk outside the East India Docks and put in casks, 5717-21. Between 1840 and 1850 the water between Gravesend and the lower part of Woolwich was perfectly good and sweet, and could be drunk at low water, 5730-3. In 1850 a good many people used to drink the water at Limehouse, but shortly after 1851 people ceased to drink it, 5736-8. The outfalls were opened from 1863 to 1866, and since then the river has become very foul from London Bridge downwards, and that is proved by the eel-schuyts being driven down to Hole Haven, 5741-4. From time to time, when the river was very bad, he has made entries in his journal, and reported the fact to the Conservators, 5746-9. In the year 1880, he was ordered by Captain Burstall to make entries as to the

## Captain CHARLES HENRY JAMES—*continued.*

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

state of the water, 5750-3. From the 29th to the 31st July he found the river between London Bridge and Greenwich very black and offensive, and on the last day Deptford Creek as well as the river were alike black and offensive, 5754-60. From the 1st to the 15th August the river was very foul and offensive, and on the 16th August it was rather improved in character, 5761-76. Then from the 17th August to the 14th September the river continued in the same foul and offensive state. Then on the 15th September it improved somewhat, but got worse again until the 21st September, when his entries end for that year, 5777-82. In 1881, from the 5th July to 4th August, the state of the river was much the same as in 1880, very foul and offensive, and improving occasionally for a day or two, and then reverting to its foul condition, 5783-800. When the river water was taken to sea it always fermented or putrefied, and the bungs had to be left out of the casks to allow the gases to escape. They would ignite otherwise if a light was applied to them, 5811-2. The general tone of the water is better than it was before the outfalls were opened, and the water is sweeter from London Bridge to Limehouse, but its condition is worse than it was in 1854. The lower reaches of the river have become fouler year by year, 5813-8. If any offensive matter comes to his district from Barking and Crossness it must traverse Captain Fitzgerald's district. His statements respecting the condition of the river are correct, so far as his district is concerned, and the difference between his entries and those of Captain Fitzgerald's entries for the same periods would be accounted for by the districts being different, 5823-35 The removal of the sewer outfalls to their present position has improved the upper parts of the river, except in very hot and dry weather, when they are just as bad as the lower parts, 5842, 5844-46.

Offensive Odours.—During the summer months of 1880 and 1881 the river was in a very foul and offensive condition, and has found a very disagreeable smell arising from it. He lives at Greenwich close to the river, and is in the habit of sleeping with his window open from May till October, but he has frequently been obliged to get up and shut it in consequence of the smell. Frequently, going up and down the river, it has made him quite ill, and he has not been able to eat his dinner when he got home, 5754-807.

Popular Evidence as to the Deposit and Accumulation of foul mud near the Main Outfalls.—Gave evidence at the "Mud Inquiry" as to the accumulation of mud banks in the Thames, which he is certain are caused by sewage. He always predicted that the outfalls would cause these deposits, as they have done, 5819-20.

Injury to Fish.—Whitebait used to be caught in the Thames at the entrance to the East India Docks, at Blackwall, but there is none to be met with in the river now, 5739-40. The eel-schuyts were driven away from Erith in 1869 to Greenhithe; then they went to Gravesend in 1870, and after two years they left for Hole Haven, where they now lie, 5744-5. Is perfectly sure that he is correct in his dates, though others may have fixed an earlier time for the departure of the eel-boats from Erith. The last did not leave till 1869. Whitebait are caught now in the Medway, 5837-41. Whitebait were not caught at Blackwall after 1851, but were caught later in Long Reach, 5843.

## Mr. WILLIAM COLLINGRIDGE, M.A., M.D., M.R.C.S., S. Sc. Cert., Camb.

Medical Officer of Health to the Port of London Sanitary Authority.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Was appointed officer of health in May 1880, as successor to Dr. Harry Leach, who died, 5847-9. Has spent a great deal of his time on the river since his appointment, principally between Westminster and Purfleet, 5850-4. During the last two years, in the summer months particularly, the river water has been extremely bad. After two or three hot days the water becomes darker, he notices black patches of sewage on the river, and there is a very offensive smell. The patches are worse in the neighbourhood of the outfalls and above, not so much below. The state of the river is foul, 5855-8, 5861-2. Any agitation in the water, such as a steamer passing through it, exaggerates the condition of the river. Has noticed

MR. WILLIAM COLLINGRIDGE—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

the water clear on the surface and foul below, and smells arise when the water is disturbed, which are not noticed at other times, 5859–60. The patches are caused by the influence of the tide or some other influence bringing up the sewage from the bottom of the river. He has taken samples of them and examined them, but not chemically. They are very thick indeed; there is a large amount of suspended matter, and the smell is horrible. He would describe them as slightly diluted sewage, 5863–6. He has frequently watched the discharge from the outfalls, and at times it can be traced for a considerable distance. (It depends very much, however, on the state of the weather and the wind.) It is a very dark smooth stream, which can be seen distinctly running side by side, as it were, with the river, which is of a brown colour. It is also distinguishable as being sewage by the small pieces of fæcal matter (sometimes in large masses), matches, corks, paper, and vegetable matter. He has traced it from Crossness to Erith. If there is any wind the surface of the river is rippled, but the sewage stream is perfectly smooth from the oily or greasy matter in the sewage, 5867–77. The last years have been exceptional years as regards the state of the river. In July 1880 it was worse than he ever saw it, though it was very bad in June 1882, when the weather was very hot. There has been very little hot summer weather during the last three years, 5899–902. In July 1880 the river was worst at the outfalls, after that it was worst at Woolwich and Jenningtree Point, and he reported the condition of the river to the Conservators, 5903–7. In 1881 the river was in much the same condition as it was in previous years, though not quite so bad as in 1880, because the hot weather did not last so long. He again called the Conservators' attention to the river, and urged the Port Sanitary Committee to take some steps in the matter; the result was that an application was made to Government, 5908–13. Hands in extracts from his reports to the Port Sanitary Committee for the half-years ending 31st December 1880, 30th June 1881, 31st December 1881, and also from a report presented on the 5th October 1882 on the state of the river. These extracts are identical with the evidence given by him on this subject, 5928–32. On the 8th December 1881 he reported to the Port Sanitary Committee the results of an investigation of a sub-committee which had been appointed to inquire into the condition of the river. Samples of water were analysed with the object of obtaining an independent result. A table showing the amount of sewage discharged from the outfalls from 1869 to 1878, and another giving the number of foul outfalls within the jurisdiction of the sanitary authority, were included in the report. An analysis of the water, with remarks by Professor Wanklyn, was also submitted, 5928–32. The large amount of fæcal matter discharged into the river from all outfalls converts what would otherwise be a tolerably clear stream into a foul sewer, 6756–7, 6791, 6833–4, 6845–6. There were, in 1881, 181 outfalls into the river from towns on the banks between Teddington and Shadwell on the north side, and 182 on the south between Ham (Surrey) and Gravesend, 191 of which were within the jurisdiction of the Metropolitan Board of Works. Some of these have been closed, while others still exist. He has received no complaints for the last 18 months of any of these outfalls being foul, but two years ago he had a great many complaints about the outfall at the Beckton gasworks, which used to discharge a certain amount of sewage mixed with gas liquor, 6758–76. Richmond and Barnes remain in the same condition as they were in 1880. At Rotherhithe two outfalls have been closed, and the rest are very small. From Greenwich to Gravesend there is no change, 6777–82. The floating population contributes a large amount of sewage to the Thames. Dr. Leach estimated the population at from 15,000 to 20,000, but witness believes it to be too large an estimate, 6783–4. In his Report of 5th May 1881 the samples which he stated to be sewage more or less diluted were not analysed, 6785–6. He condemned 30 tons of fish which were in a craft moored off Billingsgate, which caused an intolerable stench on the river from being in an advanced state of decomposition, 6792–4. The discrepancy existing between Professor Wanklyn's analysis and his own cannot be put down to the incorrectness of his method of estimating the impurities in water, 6810. The increasing impurity of the water as it comes down the river from Teddington

MR. WILLIAM COLLINGRIDGE—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

is due to the sewage which is poured into the river on each side, 6811–12. On the 23rd November 1881 he took a sample of water 300 to 400 yards from the Barking outfall, on the edge between the line of sewage and the river water, which contained one-fifth of its volume of sewage, 6813–19. At Tilbury on that occasion all trace of sewage in the water had disappeared, 6820. The upper part of the river has decidedly improved since the removal of the sewage to Barking and Crossness, 6821–5. In Limehouse Creek a nuisance was caused in 1881 by an accumulation of floating vegetable matter and a discharge from two closets. The creek was cleaned out and the closets were abolished, 6826–7. Where an outfall exists which discharges at a point below low-water mark, and it also discharges at low water, there is always some amount of nuisance, which he has noticed in certain cases, 6830–1. Of the outfalls he mentioned (*Q.* 6758, *et seq.*), by far the greater number are very small indeed, a single drain or closet. The large outfalls are very few in number, and they are at Richmond, Bow Creek, West Ham, North Woolwich, Beckton, and the West Kent outfall. Barnes has a number of small outfalls, 6835–41. The "Cornwall" is moored in a very unfortunate position, as it is a point where the sewage is carried directly round the vessel. She lies off Purfleet in a bight, 6851–2. The sewage discharged from the small outfalls bears an infinitesimal proportion to the discharge from the main outfalls, 6862–3. In no case except at Southend did the taking of the samples occupy more than a quarter of an hour. Three samples were taken at Gravesend, but he was not present. He is able to tell the time occupied by the labels on the bottles which give the actual time each sample was taken. There was only one boat manned by two men who only had to row half across the river. Six specimens were taken, three at the surface, and three at 20 feet below the surface, 11,752–7.

OFFENSIVE ODOURS.—During the last two years the river, from its exceedingly foul state, has been very offensive, and when the water is clear on the surface the foul matter below, when disturbed by the passing of a steamer, or from any other cause, causes a very bad smell to rise. He has taken samples of the black patches which rise to the surface, and the smell is horrible, 5855–65. The smells from the factories are quite distinct from the smell of the river, and with the wind blowing across the river it is quite possible to check off the factories as you come to them, 5921–3.

POPULAR EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—The mud on the banks is a dark slimy black stuff, and has a peculiar gelatinous appearance, which is particularly noticeable near the outfalls, 5918–20.

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS.—In his opinion it is impossible to pour sewage into the river to the extent it is done without serious danger to health, 5914. In hot weather he has frequently suffered inconvenience from the state of the river. It has caused distinct nausea, and in several cases actual vomiting. It has also produced diarrhœa. These symptoms are undoubtedly due to the river, for he only has them when his duty keeps him on the river for any length of time, and they disappear after he has stayed on shore for three or four days, 5915–7. Hands in extracts from his Report to the Port Sanitary Authority for the half year ending 30th June 1880, on an outbreak of typhoid fever on the steamship "Condor," which was due to bad water, and also on the health of the school ships stationed in the river, and the outbreaks of fever, &c. thereon. Extracts also were handed in from his reports for the half years ending 31st December 1880, 30th June 1881, and 31st December 1881, on the health of the training ships, 5928–32. The health of the boys on the training ships for the half-year ending 30th June 1880 was good, except a slight outbreak of scarlet fever on the "Shaftesbury" and a few isolated cases of typhoid fever on the "Arethusa." This ship appeared more liable to disease than the "Chichester," which is moored close to her, 6738–46. An outbreak of enteric fever broke out in March 1880 on the "Cornwall," into the causes of which the Local Government Board made an inquiry, the result being that it was traced to trichinosis, 6747–9. Later on in the year typhoid fever broke out in the "Arethusa" and "Cornwall," which were due in the former to the insanitary condition of the ship, and in

## Mr. WILLIAM COLLINGRIDGE—*continued.*

Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

the latter to her position in the river and the possibility of the germs of the disease having been brought down from London by the sewers. The small-pox ship has now been moved about a quarter of a mile below the "Cornwall," but on the opposite shore, 6796–6806. Since the beginning of 1881 the health of the boys has been very good, 6807–9, 6828. The health of the crews of vessels frequenting the port is fairly good, though they complain of the river when passing the outfalls, 6829. Apart from the sewage, the isolated condition of boys on a training ship is favourable to health, so far as infectious diseases are concerned, 6854–6. There can be no question that such a large amount of sewage poured into the river must produce evil effects on the health of those people who live on the water or are constantly on the shores, 6857.

Discharge of Sewage from the Main Outfalls at improper Times.—Has on several occasions watched the outfalls when the sewage was being discharged on the 30th June 1882. The sewage was discharged at 7.15 p.m., just before the flood tide, 5878–83. He has seen this on several other occasions, but can only give the dates of a few occasions. It is by no means rare to see the sewage discharged on the flood or just at low water, the effect being that the sewage is carried up the river by the flood tide. Has traced the sewage as a distinct stream as far as Blackwall. It can be traced higher up, though not so distinctly, 5884–98. It is not the fact that he had the outfalls watched for a considerable time, and that there was no discharge on the flood. They were watched for a week once in 1880, as he stated in his report for July 1880, when no discharge took place on the flood, and he said so in his previous evidence, 6733–7, 6750–5, 6787–90.

Population of Towns draining into the Thames.—In the case of the upper part of the river he is unable to state the population of the towns which drain into the river by small outlets. At Richmond cesspools exist to a large extent, 6842–4, 6863–4.

## Mr. THOMAS LONG.

Waterman in the employ of the Thames Conservancy, on board the "Conservator."

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—Has been on the Thames nearly all his life, and for the last three and a half years has been in his present situation. Before that he was working on barges doing lightering, 6042–6. In July 1880 the river was in a worse condition than he ever knew it. Lumps of stuff used to rise from the bed of the river to the surface, break open and emit a fearful stench. They seemed to be "all black mud stuff," 5945–49. In August 1881 he was sent with another waterman by Captain Fitzgerald to take samples of water at both the outfalls. They went principally at the night tides, and the four samples from the southern outfall were all taken at high water and were clear. Samples were taken from the northern outfall on five nights. All the samples were taken about two hours before high water, and on three nights the sewage was discharging, and the samples were very thick and almost black. On the 21st the sample was clear. The other two nights at the southern outfalls the samples were clear, 5950–6011. These samples were handed to Captain Fitzgerald. The bottles were put just underneath the surface. At the northern outfall they were about 30 or 40 feet from the outfall, and at the southern outfalls they were over the lip of the outfall, 6013–25.

Offensive Odours.—The patches of mud which rise from the bed of the river emit a fearful stench as they break open, 5945–9. The samples taken at the northern outfall smelt badly, 6020–3. The smells from the factories are not so bad as the river smell, and do not make him sick. A load of manure on a barge does not smell so much as when you are away from it. He never experienced any unpleasantness from it, 6035–53.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has several times been affected by the smell from the river and felt excessively sick. Others have felt the same on board. Has excellent health as a rule, but the smell makes him qualmish, 5935–44. Is ten hours a day on the river on an average, but it does not always affect his health, 6032–4. In the hot weather he feels sick even as early as 4 a.m. from the river smell, 6039–41.

## Mr. THOMAS LONG—*continued.*

Discharge of Sewage from the Main Outfalls at improper Times.—On the 19th, 21st, and 23rd August 1881, in taking samples of water from the northern outfall about two hours before high water, sewage was being discharged from the outfall. He could see it coming out through the sluices, and it washed the boat away from the sluices, 5987–6008, 6054–5. He was only about 30 or 40 feet from the outfall, and the samples he took were absolutely sewage, 6020–31. The sluices were not covered as the foreman of the works came out on the top of them to speak to witness, and at that time the sewage was flowing into the river. The arches were not covered at two hours before high water, but would be at three parts flood, 6056–63.

## Mr. GEORGE LAMERTON.

Waterman on board the "Conservator."

Discharge of Sewage from the Main Outfalls at improper Times.—He accompanied Long when they took samples from the outfalls. On the 19th August he saw the foreman of the works come out on to the top of the arches at the northern outfall, and he also saw the sewage flowing into the river. The arches would be covered about half flood, but when the samples were taken the water came half-way up the arches. The discharge washed the boat away from the sluices, 6064–75.

Offensive Odours.—The smells from the river have made him feel very queer, and they are much worse than the smells from the factories, 6080–4.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has been on the river for 17 years, and has spent his whole time on it for 12 years. Is on the river now for 10 or 12 hours a day, or sometimes all night. Has never been laid up from the smells from the water, but it has made him very queer. The smells from the factories are not pleasant, but they never make him sick, though you could not stand the smell for a long time. Is 28 years old, 6076–84.

## Mr. WILLIAM TURNIDGE.

Waterman on the Steamer "Conservator."

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been waterman on the "Conservator" for four years, and his duty keeps him on board at night sometimes. The steamer is moored at night off Charlton, and he has found the river very offensive at times, but it was at its worse state in July 1880, when the weather was so hot, 6085–95, 6103–5. Was a fisherman before he entered the service of the Conservancy, and has also been to sea. Is from 10 hours upwards on the river daily. His age is 32 years, 6106–12.

Offensive Odours.—On the 26th July the smell from the river was so bad that it made him sick, and he was obliged to leave his work. He felt very unwell for several days after. The smells have affected him on other occasions. The odours from the factories are not so strong as the river smell, nor has he ever felt any ill-effects from them, 6113–17, 6120*a*–5.

Effect upon Health in the Neighbourhood of the Main Outfalls.—The smell from the river has on several occasions affected his health, and once he had to leave his duty and lie up. He was unwell for several days. There was nothing but this sewage smell to account for his sickness, as he generally has very good health. It was 3 o'clock in the morning when he was taken ill, having been on watch all the night, 6095–6101, 6106, 6120*a*–25.

## Mr. GEORGE YOUNG.

Master of the Steamer "Conservator."

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been master of the "Conservator" for two years, and in the service of the Conservancy for 18 years. Prior to that he was a collier's pilot, and has known the river for 30 years, 6126–32, 6290. Before these outfalls were opened the river from London to Bugsby and Woolwich was very bad indeed; but in Gallion's Reach colliers used to draw their water for drinking purposes at low water up to 1864. In Barking and Half-way Reaches the water was brackish, through comparatively clear. Since the opening of the outfalls there have been very great

MR. GEORGE YOUNG—*continued.*

POPULAR EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

changes in the river. It is now a mass of sewage, which works it way up as far as Greenwich. His ship is moored at Charlton, 6133–46, 6285–87, 6291–300. In 1880 he took notes on the state of the river when it was very bad indeed. The sewage turned the paint and the composition on the bottom of the steamer quite brown, and she had to be taken to the blocks at Greenwich to be cleaned on the 26th July. The composition had only been put on three weeks before, and was quite clean a few days prior to the 26th July, 6163–75, 6250–56, 6267–72. At this time the water was so filthy that it could not be used for washing the decks or cabins, and the same state of things existed in September, 6176–83, 6243–47, 6273–76. No samples were taken at this time nor in 1881 or 1882. Samples taken for the purposes of the Sewage Inquiry were taken when he was absent on leave in August 1881, 6273–78. If the water is in a fit condition the decks are washed daily, 6288–9. The river at Charlton and Blackwall has become filthy since the opening of the outfalls, but is not so bad at Blackwall. It gradually improves as you go higher up, 6303–7. In July 1881 the river was so full of sewage that they were unable to use the water to clean the decks, and on the 18th July they were compelled to wash the decks down at Greenhithe. On the 20th July and following days they were obliged to obtain clean water from the shore for cleansing purposes, 6184–202, 6205–7, 6279–80. On the 21st July the river was in a filthy state of sewage, more especially between Barking and Jenningtree Point, 6203–4. It was excessively filthy on the 2nd August at Charlton, and the decks were washed in St. Clement's Reach. From Barking to Rainham on the 5th September it was just as bad, 6208–11. In March and April 1882 the river was in a very filthy state, and again in June, July, and October. The stink was most offensive. In March they were unable to wash the decks for a week. The sewage can be seen coming out of the outfalls, and makes a distinct track on the river. In October 1882 the bed of the river appeared to be in a state of fermentation, as patches rose to the surface and burst, throwing off a most offensive smell, 6212–29. Has been engaged for the last twelve months in taking people up and down the river on account of the Sewage Inquiry, and taking samples, 6234–8, 6279. The year 1880 was the worst, and then 1881. This year the river has not been so bad as the two preceding years, 6239–42. In 1881 the "Conservator" was undergoing repairs until the 12th July, 6248–9, 6308. On the 23rd July 1881 the water appeared to be clear on the surface, but on dipping a bucket into it 12 inches below the surface the sewage was found to be there, 6207, 6282–4.

OFFENSIVE ODOURS.—In 1880, 1881, and 1882 the river, during the summer months especially, was in a filthy state, and full of sewage. The stench from it was very bad between Charlton and Erith, 6167–229.

INJURY TO FISH.—No great change took place in the places where fish used to be caught until four or five years after the outfalls were opened. Greenwich Bight, Bugsby, North Gallions, Long Reach, &c. were the principal fishing grounds, 6148–51. Now no fishing goes on in these Reaches, 6152. Quite recently some fish brought down by the heavy rains have been caught on the shore at Charlton by children with their hands. The fish seemed to become sickly and weakened as soon as they came into contact with the polluted water, 6153–62.

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS.—On the 26th July 1880 one of his men, Turnidge, was taken ill from the effects of the foul state of the river, and he had to leave his work of cleaning the bottom of the steamer. All on the boat, including himself, were feeling "queer" that morning, but were not incapacitated for work except Turnidge, 6251–5, 6268–71. Twenty years ago, when the upper part of the river was so foul, he had an attack of cholera owing to its condition, 6298.

MR. JOHN PHILLIPS, Putney.

Formerly Chief Surveyor to the Metropolitan Commissioners of Sewers.

METROPOLITAN MAIN DRAINAGE, PAST AND PRESENT.—In 1847 he was appointed Chief Surveyor to the Metropolitan Commissioners of Sewers, who had the entire management of the sewers of the Metropolis until they passed into the control of the Metropolitan Board of Works in 1855, 6313–6. He had considerable practical experience in work of this nature, 6317–8. In 1847 he made experiments in the Westminster sewers and ascertained that sewage must flow with not less velocity than 2½ feet a second both in the large and branch sewers in order to prevent fæcal and other matter in suspension from depositing, 6319–21, 6387–90. There are hundreds of miles of sewers in London now where the velocity is less than 2½ feet a second. These are called "deposit" sewers. They have nearly flat bottoms, with upright sides and arched tops. To concentrate the flow and maintain the velocity, the sewer should be shaped like the letter V, 6322–6. The sewage at this time was discharged into the Thames, and the outlets were considerably above the low-water level. Old London Bridge dammed up the water, and the level at low water was four or five feet higher above the bridge than below it. The removal of the bridge brought the water to the same level, and enabled the flat marshy districts above Westminster to be drained lower than before, 6327–31. Wooden trunks had then to be fitted to the outfalls extending down to low water, to prevent the sewage spreading over the banks; but it had very little effect, as the flood-tide brought the sewage back again, making the banks as bad as they were before, 6334–8. In 1846, in conjunction with Mr. G. Hawkins, they ascertained from gauging and other experiments that 1,798,094 cubic feet of sewage were discharged into the Thames at Westminster daily, which corresponded pretty accurately with the daily water supply to the houses, 6339–42. Each house had from one to three cesspools, communicating with the sewers by an overflow pipe. In 1848 they began to abolish cesspools and substituted waterclosets, 6343–5. He calculated that the capacity of these cesspools was equal to a canal 20 feet wide, 5 feet deep, and 10 miles long. Sewage enough to fill this hypothetical canal was therefore poured into the Thames, 6346–51. In 1849 there was a serious epidemic of cholera, and it was considered preferable to allow the sewage to be discharged into the river than to detain it in the cesspools, and decompose there. The river in consequence became so foul that it caused an outcry, which led him to consider the question of preparing a system by which the sewage not only of London, but of all the towns in the Thames Valley from Windsor, might be carried off, 6352–6. Mr. F. Forster was appointed engineer to the Commissioners, and he was directed to prepare a scheme for the disposal of the sewage by means of outfalls, which was submitted to the Commissioners in 1850, 6357–65. Has frequently removed the "deposits" from the sewers and found them to consist chiefly of night-soil, and house and street refuse matter, which form the compound known as sewage, 6383–6, 6388–9.

SET OF THE TIDE.—In 1851 the engineer to the Commissioners of Metropolitan Sewers directed him, in conjunction with Mr. Betts, to make a series of tidal experiments after the sites for the outfalls had been fixed. They were made by means of a wooden float, six feet long, and extended over various days. He followed the float himself in a boat, and reported the result to the Commissioners on the 8th July 1851. (The particulars are given in that report, which is printed in the evidence, *see* 11th day), 6366–76. On the 11th September 1851 he reported the result of a further series of experiments, which is also given in the evidence, 6377–80. All these experiments were made during the summer, which was fine and dry, 6381–2. The float was always kept in the full strength of the tide, and when it showed a tendency to get into slack water it was hauled out into the stream. The results show, therefore, the greatest velocity, and not the average velocity, of the tide, 6391–3.

POPULAR EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—When old London Bridge was removed, the water which had been dammed up by the pier fell from four to five feet to the level of the water below the bridge, and consequently exposed more of the river banks than formerly. The sewage discharged from the sewers spread all over the banks and caused a deposit of sewage mud, which increased until the surface became covered with myriads of small red

## Mr. JOHN PHILLIPS—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

worms. Wooden trunks fitted to the outfalls to carry the sewage down to low water had little or no effect, for the flood tides brought the sewage back again and spread it all over the banks, which became as bad as before, 6331–8.

## Captain EDWARD BURSTAL, R.N.

Secretary to the Thames Conservancy Board.

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—Has known the river since 1832, and was employed in that year under Captain Bullock in surveying the river for the Admiralty. In 1861 the Conservators ordered a survey to be made on the same scale, and on comparing the two charts he found very little difference between them, 6394–6402. Between these two years a great many hand-dredgers were at work, and the spits at Leather Bottle Point and Jenningtree Point, both in Half-way Reach and on the south side of the river, were dredged away. This would have the tendency to conduct the stream more to the middle or south side of the river, both on the flood and ebb tides, 6403–7. The Dagenham shoals and other banks were also removed, 6408–10. Rand's Hill has been removed since 1861, as it appears on the chart, 6411–13. There is a quantity of mud deposited on the south shore between Margaretness and Leather Bottle Point, and on the north shore below False Point. It has accumulated since the outfalls were opened, and is composed of very black mud, very deep and very slimy, and not much sand or gravel. It is totally different to mud found in other parts of the river, and smells badly in warm weather, but not in cold weather Has found no smell in mud taken from the middle of the river opposite the outfalls in cold weather, 6414–23, 6428–33. The bank in Barking Reach is caused, in his opinion, by the dirty muddy water being stirred up by steamers going over the shoal off the southern outfall, and it is carried up by the flood tide, and it is deposited in the slack water in Barking Reach, 6433*a*–4. Colliers drawing 16 feet of water used to come up the river and lie in Half-way Reach until their cargoes were sold. Now there is about seven or eight feet of water there, 6435–9. The fairway for many years was right down to the southward of mid-channel of Half-way Reach, 6440. About three years after the outfalls were opened the Conservators directed a new survey of the river to be made, on account of the filling up of the river, and it was compared with the chart of 1861. It was found that a large mudbank had formed off the southern outfall, and water of only 8 or 9 feet at low spring tides where formerly there were 16 feet, 6441–5. Owing to dredging in Erith Reach, shoals which were marked on the 1832 chart did not appear in 1861, and the depth of water was consequently greater. The low-water mark at Erith was also closer to the shore, 6446–9. In 1879 another survey was made, and there is a large accumulation of mud in Erith Bight all along the shore to the vertical depth of from 8 to 10 feet; the depth of water had also decreased from Erith church, past the Club causeway down to the pier, 6450–6. The mud is black and very similar to that which he described further up the river, 6457–9. A further survey was made in October 1882, which shows that the accumulation is still going on, 6460–1. In 1879, in consequence of a petition from the inhabitants of Erith, the Conservators lengthened the causeway 50 feet, as it was covered with an accumulation of mud, and the Yacht Club for the same reason have also lengthened their causeway. There are only two or three feet of water at low tide now at the warping buoy, where formerly the depth was 13 feet, 6462–76. He cannot attribute this accumulation of mud to the removal of a shoal in the middle of the river three-quarters of a mile below Erith. The water would rather be deepened thereby, 6477–84, 6528. The accumulation of mud in Erith Bight is caused by the dirty water from the sewers, 6501. He gave evidence at the Mud Inquiry, and the only banks that the Conservators elected to have dealt with by the arbitrators were those in Barking and Half-way Reaches. No mention was made of Erith in that inquiry, 6504–12. Although he has stated in his evidence that the accumulation of mud at Erith has interfered with the landing of people at the causeways, and so to a small extent with the navigation of the river, the Conservators did not think it worth while to bring up the subject at the Mud Inquiry, and he would not have referred to it to-day but for the memorial of the Erith

## Captain EDWARD BURSTAL, R.N.—*continued.*

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

inhabitants, 6513–6. The greater part of Rand's Hill was dredged away between 1832 and 1861, not since 1864, although part of it may have been, 6517–22, 6572. The sectional area of the river cannot have been much increased by the removal of this shoal, and he does not believe much in sectional areas, 6523–7, 6592–3, 6601. His evidence before the Rivers Pollution Commission as to the muddy state of the Thames did not refer to the neighbourhood of Erith, of that he is certain; but he has no doubt that the wash of the steamers passing up and down the river has caused a considerable degradation of the "saltings," 6530–7. The saltings are the green swards that lie between the back river walls and the foreshore. They are impregnated with salt, and cattle feed on them during neap tides, 6538–9. Screw steamers do not cause such a wash as paddle steamers, but they churn up the mud where a new shoal is forming and so create shoals on the flood, 6540–3, 6548, 6563–4, 6622–4. The condition of the river was very bad before the outfalls were opened from Greenwich to above Westminster, and there always has been a quantity of mud in it, but when he knew the river first there was very little mud floating about in it anywhere. Since the sewage was poured into it, first of all in 1845, the state of the river has been filthy, especially during 1857, 1858, and 1859, in the neighbourhood of the metropolis, 6454–7, 6549. Dredging was carried on in the various Reaches of the river between 1859 and 1879, as shown by the log-book of the late Mr. E. J. Smith, formerly commander of the "Conservator," but to what extent witness cannot say. The machines were probably bag and spoon dredgers, 6573–86, 6630–6. Referring to Q.Q. 6517–22, he has ascertained that the large middle shoal in Erith Reach was removed before 1853, and he produces a plan made by the master of the Trinity dredger "Goliath," who worked on that ground in 1853, 6593–600. Is aware that, generally speaking, other tidal rivers are quite as muddy, if not more so, than the Thames. The Medway certainly is, 6608–9. Spoon and bag dredgers are people who dredge for their own profit and sell the gravel. Steam dredgers belong to the Trinity Board. The quantity dredged by the former is small compared with the latter, and would not hold more than 40 or 50 tons. They obtain licenses from the Trinity Board, for which they pay a fee, 6637–44. A record is kept of these, which he will produce, 6645–55. *He hands in some sections of the river which have been prepared under his superintendence (see Appendices D., E.),* 6656. They relate solely to the south side of the river, and were drawn to show the deposit of mud at Erith, which has been so often referred to by witnesses from that place. He does not allow that the silting is due to the deepening of the north side, 6657–62.

Effect upon Health in the Neighbourhood of the Main Outfalls.—It is a fact that the condition of the river was such as to produce vomiting and sickness in those who worked upon the river, himself amongst the number. He had a sore mouth very often and all the mucous membrane of the lips and mouth were made bad by the offensive smell while engaged in surveying the river, 6561–2, 6629. Many men on the "Citizen" steamers, about the year 1856, were affected by the foul state of the river, and were attended by Dr. Ord, at St. Thomas's Hospital. There was not much illness amongst piermen, bargemen, and the Custom House officers at this time, 6625–9.

Injury to Fish.—About the year 1866 the fish had to a great extent disappeared from the river between London and Woolwich; and the eel-schuyts left the upper Reaches of the river before the outfalls were opened, he believes, 6565–71.

Distribution of the Sewage in the River by the various Motions of the Water.—On the 14th July 1882 he took the set of the stream by putting a float in at Barking Creek close outside of low-water mark. It drifted with a strong stream on the north shore to False Point It then gradually set off past a bay, where there is slack water and a large deposit of mud, taking a middle course down Half-way Reach. Another float put in at Leather Bottle Point, on the south shore, followed a course parallel with the south shore until it got below the outfall. The velocity of the current was 2½ miles an hour. On the north side the velocity was 2¾ miles an hour, 6427–34*a*, 6496–8, 6556–7. Hands in the results of his observations on the float experiments, 6499–500. In 1856, by order of the First Commissioner of Works, he made a series of float experiments to observe the

## Captain EDWARD BURSTAL, R.N.—*continued.*

Distribution of the Sewage in the River by the various Motions of the Water—*continued.*

strength and direction of the tides between Putney and Woolwich, specially with reference to the new Westminster Bridge and its foundations. The result of these experiments he reported to the Commissioner of Works, and the floats travelled from 12½ to 14 miles a tide. He hands in a table containing the result of his observation of the stream (*see* Appendix C.), 6485–93. In 1856 and 1857 the sewage poured into the river oscillated backwards and forwards, passing London, as the river had not the same power to carry the sewage to the sea as at Barking, and the conclusion he came to after making his experiments was that the sewage would be carried down from Barking to the sea at the rate of five miles a fortnight; his opinion has not varied from what he stated in 1857 and 1866, 6550–4. Under the impression that the sewage would be discharged at high water when the outfalls were opened, he stated in 1866 that the sewage would be carried down to the sea and be no more seen. He thinks now it would have been better to discharge it lower down, where there is a stronger stream to carry it away, 6555–60. 6619–21. Sir J. Bazalgette took no actual part in the experiments of 1856. He simply came down to Woolwich one day for an hour, and the plan to be adopted was explained to him, but he never went on the river, 6587–91, 6602–7. In 1856 he recommended that the outfalls should be placed at Rainham Creek and Jenningtree Point, while the referees proposed that the outfalls should be below Mucking Lighthouse and below Gravesend. He thought that if the discharge began at high water the river would be safe from pollution in the neighbourhood of London, 6610–8.

## Mr. EDWIN HUGHES, Green's End, Woolwich.

Solicitor to the Woolwich Local Board of Health.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls—Is chairman of the Sanitary Committee of the Plumstead District Board, and was for 20 years a member of the Woolwich Local Board. Has lived, and carried on business, in Woolwich since 1845, and is well-acquainted with the locality and its requirements, 6663–71. Knows the river well, and has travelled on it frequently. In hot weather the condition of the river is very bad, and is getting worse. The cause is due to the discharge of the sewage at the outfalls, 6672–6. The sewage of Woolwich is taken into the metropolitan sewers, but the drainage of North Woolwich and part of East Ham is carried into a reservoir which discharges direct into the river. The Metropolitan Board contributed to the expense because they would not connect North Woolwich with their system. This discharge at North Woolwich contributes to a small extent to the pollution of the river, 6677–84. The Lea is rather worse than the Thames, and flows into the river at Blackwall, which is not in the Woolwich district, 6685–6.

Offensive Odours.—The river has a smell in hot weather, and so have the factories, but he is able to distinguish between the two, 6692–3.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls. — There is a great increase in the filth on the banks of the river from Woolwich to Erith since the opening of the outfalls; it is black now, and an artificial mud. Formerly it was brown in colour, 6687–93, 6696, 6700–4. It is impossible to land now from a boat in many places on account of these mud-banks. There are some at Woolwich Pier, but it is worse at Crossness, 6694–5, 6705–6. The accumulation has been going on gradually since 1864, at Woolwich in the bight between the dockyard and arsenal, and on the north shore between the gas works and the northern outfall, 6737–14.

Effect upon Health in the Neighbourhood of the Main Outfalls.—The general condition of health in the district is very low. There have been 173 cases of low fever at Plumstead during the last twelve months, but the proportion of zymotic diseases is extremely low at Woolwich, 6717–23. Plumstead is more bounded by the river than Woolwich, and the cases of fever have occurred within a mile and a half from the river. Since the railway has been constructed ague has ceased because the railway cutting ventilates the marsh, 6724–7. Zymotic diseases have been prevalent on the side of the town nearest the river, which is distant about three-quarters of a mile, 6728–30. The sanitary condition and general health of Woolwich is fair, 6718–32.

## Mr. JAMES MOORE MASON, East Greenwich.

Member of the Greenwich District Board of Works.

Capacity of the Drainage System as compared with the Demands upon it; Influence of this upon the Storm Discharges.—The main outfall sewer passes from the Deptford pumping station along the Trafalgar and Woolwich Roads through Greenwich, and the whole of Greenwich is drained into it, 6865–72. For some time the system worked well, but for some years during heavy rains the sewer is incapable of holding the amount of sewage which comes into it, and it overflows into the basements of the houses in the neighbourhood, and in some instances it has flowed through the gullies or traps on to the main road. On one or two occasions he has known it force open the man-holes, when locked, in Greenwich Marshes, and flow through the ditches into the Thames in considerable quantities. It raised the level of the water in the ditches several feet, 6873–91, 6903. This has happened within the last three years during an exceptionally heavy fall of rain, 6892–7. The Metropolitan Board of Works are now constructing a new sewer which runs from the Lewisham district and joins the old sewer at Deptford Creek, which will relieve the Lewisham district, 6898–902, 6905–10. The pumping station at Deptford is insufficient for taking away the whole of the sewage that comes into it, 6903, 6911–2.

## Mr. GEORGE ROBERT MASON, Lower Road, Deptford.

Market Gardener, and Member of the Deptford and Greenwich District Board of Works and Local Board.

Capacity of the Drainage System as compared with the Demands upon it; Influence of this on the Storm Discharges.—Has known the sewer in Greenwich Marshes to overflow after a heavy rain and emit a large quantity of sewage. On one occasion it blew the tops of the man-holes off. The water flowed into the ditches and from thence into the Thames. The overflow has happened more than once, 6913–21, 6927. His attention was drawn a fornight ago to an accumulation of garbage in Deptford Creek, which came from the storm outfall there. There was about a cartload of it, 6922–4, 6930–1, 6936. Believes the sewage has caused damage to barges in the creek, 6925. His Board has more than once complained to the Metropolitan Board of Works about the overflows, 6928–9. His tenants in Deptford have complained to him of the stench from the river, which is continually getting worse, 6917.

## Mr. GEORGE JAMES SYMONS, F.R.S.

Past President and now Secretary of the Meteorological Society.

Rainfall to be provided for.—Is editor of a publication on British Rainfall, and receives returns from over 2,000 stations in the kingdom. Almost exclusively, since 1860, he has devoted his attention to the distribution of rain, 6937–40. Until recently rain-gauges have been used which were only capable of giving the total fall during 24 hours, and not showing during what period the rain fell. Since 1875 gauges have been constructed which are self-recording, and write down the quantity minute by minute as it falls. There are four such gauges in the metropolis, 6941–2. One of these gauges is at Greenwich Observatory, one is at Mr. Latham's at Croydon, a third witness has at Camden Square, and the fourth is at Kew, 6942. Hands in a book containing the results of Mr. Baldwin Latham's observations on rainfall at Croydon, 6942. The observations published from Kew he has carefully considered, and as possibly the sewage does not pass through the sewers at an uniform rate, they might be capable of taking $\frac{3}{100}$ths of an inch of rainfall per hour instead of half that amount as suggested by Sir J. Bazalgette. Besides in very dry weather $\frac{1}{100}$th of an inch would not flow into the sewers, therefore in his calculations he has allowed $\frac{4}{100}$ths of an inch per hour, and on this basis he has carried out his investigations for four years, which give very nearly the same results, and he does not think it necessary to go further back than 1880. He has prepared tables which contain the hourly rainfall at Kew on days on which the fall reached or exceeded one inch per diem (·04 of an inch per hour equals ·96 of an inch per diem), 6943, 6949–50. The abstract shows that in 1880 there were 83 days, in 1879 there were 95 days, in 1879 there were 82 days, and in 1877 there were 104 days, when there was a fall of ·01 inch per hour and upwards, giving an average of

MR. GEORGE JAMES SYMONS—*continued.*

RAINFALL TO BE PROVIDED FOR—*continued.*

91 days per annum. During the same period the total number of days when the fall reached ·10 inch per hour or upwards were 41, 37, 38, and 35 respectively, giving an average of 38 days. *He hands in these tables*, 6943, 6952–4. He ascertained 15 years ago that the number of days in the year on which the rainfall in the whole 24 hours exceeded a quarter of an inch was 35 days ("British Rainfall," 1867, p. 28), 6944–5, 6955. Since that period the rainfall has been above the average for the last few years. Not being an engineer, he is unable to say whether a quarter of an inch of rain would come into the sewers at any appreciable time of its falling, but everyone knows that with violent rain it rushes into the sewers, especially where it falls on macadamized roads and pavements, 6956–7. Hands in some tables which represent in a convenient form the amount of rain measured at certain places, of which the names are inserted thereon, and of which the positions are shown by numerals on the maps which he hands in (*see* evidence of Mr. Whitaker, F.G.S., following this evidence, with reference to the maps). *See Appendices F. and G. for these tables*, 6946–7. Hands in a diagram showing by columns the amount of rain falling at Oxford as representing the upper watershed of the Thames, and at Camden Square as representing London. These will form a rough guide to the Commission as to the distribution of rain, 6948. The total annual rainfall in London is 24½ inches, 6951. He has no record of the area over which the quarter of an inch of rain falling extends, but no doubt it should be known in calculating the amount which enters the sewers. He is, however, sure that there is nothing exceptional in the frequency which is shown at Kew. Very heavy rainfalls of two or three inches in an hour or two are intensely local, and does not apply to values such as are given in his tables. A fall of upwards of an inch per hour is usually a local fall, 6958–66. In five years he has had two instances of 2¾ inches of rain, and there have been perhaps eight or ten falls exceeding an inch per hour, but he adheres to his original statement that the average of 90 days is not disturbed to the extent of 10 per cent. by local falls, 6967. The fall of rain registered at Kew may be taken as a fair sample of the general rain over the metropolitan area, 6973. Sir J. Bazalgette's statement "that a quarter of an inch "of rain in 24 hours is an extraordinary thing" he does not understand, for it seldom rains without $\frac{1}{100}$th of inch falls, and in his tables there is no entry taken out which does not exceed ·04 inch, and the great bulk of the entries is much larger. He has underlined in the tables all the instances which exceed $\frac{1}{10}$th of an inch per hour, and they are ten times the quantity which Sir J. Bazalgette speaks of, 6974–6. The general difference between the minimum and maximum varies from $\frac{5}{10}$ths inch to $1\frac{9}{10}$ths inch, 6978. At Hampstead 4¼ inches fell on one occasion in 24 hours, and at his house 2¾ inches fell in 1¾ hours. It was the heaviest rain he ever knew, and the New River Head on that occasioned registered under half an inch, 6977–9. On one occasion he noted a rainfall $1\frac{1}{10}$th inches which had fallen equally over the metropolis. He compared it with the whole of the South of England, and there was a difference only of $\frac{1}{10}$th inch at all the stations up to the latitude of Bedford, 6980. Heavy rains as a rule are rains of very short duration, and his tables show when they were short or long, 6981–3. If it is desired he will tabulate the rainfall at Camden Square for comparison with the rainfall at Kew, 6984.

MR. WILLIAM WHITAKER, B.A., F.G.S.

EFFECT ON WELLS NEAR THE RIVER.—Has been engaged on the Geological Survey of England for more than 25 years, and has mapped the greater part of the Thames Valley, 6985–9. The question of water in the chalk is a subsidiary subject to which he has paid a good deal of attention, 6990. It is a very common thing in the Thames Valley, as along other water borders, that wells should rise and fall with the tide to a greater or lesser extent, and in some cases the water in the wells becomes brackish by reason of the infiltration of river water, 6991–3. He describes at length the geological formation of the Thames Valley above and below London, 6994, 6999–7016. Between London and Windsor there is very little chance of infiltration of water through porous strata into the earth owing to the impermeable bed of London clay along the course of the river. Its thickness varies from 300 to 400 feet.

MR. WILLIAM WHITAKER—*continued.*

EFFECT ON WELLS NEAR THE RIVER—*continued.*

The gravel which forms the bed of the river lies on this clay, 6995–8. Of the beds below the London clay (going down the river), which are four in number, the Blackheath beds, consisting of sand and pebbles, the Thanet sands, and the chalk are thoroughly permeable throughout, but the Woolwich beds, which consist of clay, sands, and pebbles, are permeable only as regards the two last, 7004–16. The deposits of mud on the bed of the river would to a certain extent prevent infiltration of water into the permeable strata, but at the bottom of the river there is really very little mud. Where it does exist it is simply local, 7017–8. Below London there is plenty of opportunity for the infiltration of river water into the beds from which the water supply may be drawn, and if the river is charged with sewage, naturally the sewage will permeate into the beds. If water be pumped from these beds to any extent it tends to lower the fresh water and to produce a cone of exhaustion which might result in drawing in the foul water, 7019–23. There were two pumping stations of the Kent Waterworks Company at Charlton, about a third of a mile from the river, but the company has discontinued the use of these wells for some years, 7024–7, 7045–6. It would take some time for wells to become polluted, because the river would not contain enough foul matter to have any effect for a long time, and it would take some time before the pumping at the wells would draw in such water. As the pollution of the river increases, and the pumping increases, conditions are set up which are favourable to the drawing in of river water into the wells, 7028–30. The chalk basin under and around London is a great water-bearing stratum, and where it is bared to the river it would feed the river under natural conditions. It is also the case, though to a lesser degree, that the chalk in the upper beds is a water-bearing strata, but there would not be so much pressure there, 7031–6. Has not gauged any wells in order to observe the fluctuations with the tides, but has received records and information on the subject, 7036–9. The chalk at its outcrop gets a considerable amount of rainfall into it, 7042. If a well is sunk near the Thames it draws water equally from the uplands as from the river side, 7043–4.

MR. EDGAR SHAND.

Manager of the London Steamboat Company.

POPULAR EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—Was born on the banks of the Thames, and has been conversant with the river all his life, 7047–9. Has seen the sewage discharged from the outfalls, and has been able to trace it. Has seen the sewage flowing up and down in all parts of the river, but more particularly between Greenwich and Woolwich. It was very bad at Woolwich, 7050–5, 7067, 7071–2. The river was worse in the summer of 1881 than he has ever seen it. It was very thick, with a sort of glutinous matter, and bubbles rose and burst, and he saw nightsoil floating about. The smell was fearful, especially when the paddles of the steamers stirred it up. He has received frequent complaints of the filthy condition of the water from passengers, the captains, and the men on the boats, It has made them sick. In the winter the water is much better, 7056–64, 7070. Is on the river daily in the summer time between Greenwich and Woolwich, 7065-6.

MR. HENRY JONES, Woolwich.

Fisherman.

POPULAR EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—Has known the river for a long time and used to gain his living by fishing. Now he collects the fat off the river from a boat by means of a landing net, and steams it on a barge he owns which is moored in Barking Creek, 7073–84. The fat is blown by the wind to various parts of the river, but he finds it principally in the bays of the river from Blackwall to Purfleet. There is often a large quantity in Barking Creek which comes from the outfalls, and when there is no wind they collect the fat at the outfalls. There is no disagreeable smell from the fat, which, when steamed, he sells; but he does not know to what purpose it is put, 7085–92, 7095–8, 7100–6. He generally starts to collect the fat on the half-flood tide, but he is dependent to a certain extent on the direction of the wind, 7093. He enjoys pretty good health, 7099.

### Captain HENRY WEBB.

Captain of the Steamer "Cupid," plying between Woolwich and London Bridge.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been employed on river steamers for nearly 40 years, and holds a Trinity House pilot certificate. He knows the river thoroughly, 7107–10. Prior to the opening of the outfalls the river between Westminster and Woolwich was worse than it is now; but the outfalls have made the lower part of the river foul and cleared the upper, 7111–5. Above the outfalls in the summer time he has seen the water very black and smelling badly, and he has frequently had complaints from the passengers of the stench from the river. It was worse the year before last. The steamers stir up the mud at the bottom of the river. It is worst from Barking to the lower part of Half-way Reach, 7116–22.

Offensive Odours.—When the steamboats get under weigh the paddles stir up the mud, which causes a very great stench. It is also very bad when two boats pass or run down together. The passengers have to keep their handkerchiefs to their faces to avoid the smell, 7116, 7120–1.

Set of the Tide.—Is acquainted with the tides in the river, and the flood tide is stronger than the ebb tide, 7123–4.

Effect upon Health in the Neighbourhood of the Main Outfalls.—He enjoys very good health, and seldom requires the services of a doctor, 7125.

### Captain THOMAS HUNTINGFORD.

Captain of the "Duke of Edinburgh," belonging to the London Steamboat Company.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He holds a Trinity House certificate as master and pilot, and has known the river all his life, 7126–8. The sewage when discharged from the outfalls extends 200 yards into the body of the river, and the line is clearly shown by the colour, 7129–31, 7156–8. In Half-way Reach the water is never clear owing to an eddy, from which the sewage never gets away, 7132–4. From Bull's Point, abreast of Woolwich Arsenal to North Woolwich Pier, the water is in a very bad condition, and the stench there is worse than at any other part of the river. The first quarter flood sets in there, and a down current brings it back past the Gardens to Bull's Point, so the sewage cannot get away on account of this eddy, 7139–43. There is a drain pipe, two feet in diameter, near the Telegraph Works, above the Ferry Pier, but he has only seen water come from it after heavy rains. He has never noticed any smell from it, 7144–51, 7155. The pipe comes down to low-water mark, 7154. He has traced the sewage from the outfalls nearly a quarter of a mile up the river up to Halfway House Point, and down the river to Jenningtree Point; after that the river becomes one colour, but very thick in both directions, as far as Greenwich and Greenhithe, 7156–67.

Offensive Odours.—From North Woolwich Pier to Bull's Point the smell is very bad, and the paddles of the steamers stir up the mud and throw up the scent from the river, 7139, 7152–3.

Set of the Tide.—There is not sufficient run of the tide to carry the sewage through Halfway Reach after the first quarter flood or ebb tide, for then an eddy begins to form on account of the tide setting strongly from Jenningtree Point to the Dagenham shore on the flood, and from Halfway House Point to Dagenham on the ebb. A north-west wind would carry it away lower down the river, 7135–8.

### Mr. EDWIN MARTIN.

Pier Master at South Woolwich.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Has been stationed at South Woolwich for 18 years, and was pier-man before he was Pier Master. Prior to that he was in the Navy, 7168–72, 7190–6. The water in the river was in a much better condition and clearer then than it is now. Flounders and shrimps could be caught there, 7173–5. When the sewage is discharged on the flood, the water becomes very black, and little balls of fat float past, especially after heavy rains or snow, 7176–82. Has seen these balls of fat hundreds of times this summer, 7188–9.

### Mr. EDWIN MARTIN—*continued.*

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—At times mud collects about the pier, and sometimes it shifts. The tugs stir it up, and the stench is simply awful. The mud is of a bluish black colour, and is not at all like ordinary Thames mud with which he is familiar, 7183–6.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Has been absent from duty for three days at a time, twice this year through illness, but he cannot positively attribute it to the smell from the river or the mud, 7187.

### Mr. BALDWIN LATHAM, F.G.S., F.M.S.

Member of the Institution of Civil Engineers.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—Is a civil engineer practising at Westminster, 7197. And has devoted his attention for a great many years to works connected with sewage and drainage, and to tidal outfalls, 7198. Hands in a report on the observations made in the river by himself. (*See Appendix R.*) Has taken the temperature of the water for many years, and knows at what temperatures it would become noxious. When at 60° or 65° to 70° it is noxious. Hands in two tables of recorded temperatures of the Thames, showing the number of days in every month when the temperature of the Thames water was above 60°, the number of days when it was above 65°, and the number of days when it was above 70°. The number of days when no observations were taken is also given. The maximum and minimum temperature for each month in the year, from June 1844 to October 1879, is shown in one of the tables, 7414–5, 8367–70. The temperature was taken at 9 a.m. daily by thermometers attached to the side of the "Dreadnought" till April 1870. From 12th January 1871 to May 1874 they were attached to the "Scorpion" in Blackwall Reach, and from that time until October 1879 the thermometers were fixed to the "Royalist," which was moored in the same place. The thermometer was immersed a foot below the surface in running water, 7416–23. Hands in a table of temperatures giving the monthly means, through a range of 35 years, of the principal elements of the temperature of the water of the Thames, compiled by Sir George B. Airy, K.C.B., F.R.S., 7430. The fact of the sewage staying in the river in hot weather, assuming it to be not mixed, tends to make it more noxious, because when the weather is hot, decomposition of the matter deposited and held in suspension takes place, and the tidal water is filled with the gases of decomposition, and is not capable of oxydising the impurities of the sewage, 7449, 8371–6. Hands in a table taken forom the analyses of Professor Way on samples of water taken in the river at various points between Chiswick and Margate, giving the amount of chlorine in 100,000 parts at high and low water on the 14th and 22nd of September 1882, and on the 30th November 1882, 7510–5, 7989–92. Given the amount of chlorine in one fluid and also in another, you can tell the amount of chlorine there ought to be in the mixture, and inversely, you can with the same data tell the relative proportions of the mixture, 7516–21. To find out in what ratio a certain volume of water is mixed, he uses the following formula:—

A=the chlorine in sea water.
B=the chlorine in the river water.
C=the chlorine in the mixed water.

Then $\frac{A-C}{C-B}$ = the exact result.

This is taking a simple compound, but where there are three separate fluids mixing, it can be dealt with in the same way. The object of these calculations is to find out by means of chlorine the proportion of sea water, river water, and sewage in every part of the Channel, 7516–24, 8321–30. Has worked at great length a more elaborate mode showing how this formula is deduced, and hands it in (*See* Appendix U.), 7525. Taking it generally, the object of these chlorine experiments is to distinguish what is sea water and what is not sea water. They are much more important down the river, and the lower down you go the greater is the effect of the mixing action, because if it did not take place, there would be the same amount of river and sea water all the way down, 7526, 7527. In making these calculations, he took the actual volume of water known to come down the river upon the same day, and a standard of sewage by taking five cubic feet per head of the population, because if there was anything to increase the amount of

MR. BALDWIN LATHAM—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

sewage, there would be the same amount of chlorine going in although in a larger volume. If it rained, the sewage would go into a larger volume of water. The amount of fresh water coming into the river every day at every point of the river is known, and so is the standard of sewage. He assumes the mixture of river water and sewage to be of the same proportion as the daily flow of the water and sewage, and knowing the amount of chlorine in each, it is easy to see what is the amount of chlorine in the two mixed. It is correct to assume that they are mixed in the ordinary proportions, because if there happens to be a larger amount of water coming down, it is measured in river water, while there is the same measure of chlorine coming from the population, 7528–35, 8484–9. The sewage and fresh water are mixed so as to form one fluid, which then mixes with the sea water. The amount of chlorine is taken as indestructable, 7536–9. Gauges have been placed in fifty different places, so that with the exception of the 284 square miles, which are equal to $\frac{1}{18}$th of the whole drainage area of the Thames, he has ascertained the quantity of water coming into the river every day, 7540–2.

The amount of chlorine in sea water is 1961 parts in 100,000. The amount of chlorine in fresh water is 1·7 parts in 100,000. The amount of chlorine in sewage is 10 parts in 100,000.

The amount of chlorine in a combination of sewage and fresh water varies in different parts of the river. Below Barking it is constant, but above it is less. For the purpose of ascertaining the relative amount of sea water and non-sea water it is not material to distinguish between the sewage and the fresh water, 7543–9. Hands in a table showing the amount of chlorine in 100,000 parts in the component volume of river water and sewage combined at 10 places between Teddington and Southend where samples were taken on the 14th and 22nd September, and the 30th November 1882, 7548. On the 22nd September there was 50 per cent. more water coming down than on the 14th September producing more dilution, and on the 30th November the river was in flood. It caused a difference of 40 per cent. less chlorine at Southend. The highest flood going over Teddington Weir is distinctly appreciable at Southend, 7550–6, 8315–30. The difference between this table and Professor Way's is caused by its representing the amount of chlorine in river and sewage water combined, whereas Professor Way's includes sea water, 7557. Chiswick may be taken as the vanishing point of sea water, and at Barking it is in full volume. If you take the mean between the two, it will show that there is only half the chlorine due to sewage in that part of the river which is observed at Barking, 7557–8.

The table handed in yesterday (*Q.* 7369) shows the quantity of river water in the mixture all the way up the river as well as how much sea water there is. For example, at Chiswick $\frac{1}{7.50}$th part of the volume was sea water; at St. Paul's Pier $\frac{1}{3}$th was sea water; at Erith there is about an equal quantity of sea water and of sewage and fresh water mixed, and so on, 7559–65, 8224–5, 8315–35. He now hands in an amended table showing the effect of the mixing action in the River Thames (*Q.* 7369). From it, it is found that as regards the upper reaches, the number of days it takes the sewage to get out is increased, but below Barking the results are not altered, 7566–7. Starting at Deptford, on the 14th September, the sewage discharged at high water from the outfalls would take 41 days to get to the sea, and 40 days at low water. On the 22nd September, there being more water in the river, it would take 34 days and 31 days at high and low water respectively. On the 30th November, the times are 16 and 12 days respectively. His reason for starting at Deptford is that the sewage, after being discharged, would be brought back to Deptford by the next tide, 7568–73. Displacement and mixing action have both been considered in these calculations. In flood time the mixing action and displacement are both greater than in dry seasons, the difference in mixing being 30 times taking the whole basin of the Thames, 7574–6. The want of sufficient capacity in the reservoirs, and the frequent discharge at other points of the river, leads to the pollution of the higher portions of the river, and shows that there is an accumulation of the sewage which would not otherwise take place, 7670. The outfall at the Beckton Gas Works was made in 1874.

MR. BALDWIN LATHAM—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

The average total quantity of water flowing out of it daily has been found by gauging to be 292,952. gallons, or 46,872 cubic feet, per day. No solid matter goes through the sewer, as it is filtered through coke, but the water smells very strongly of gas. There are 101 cottages on the property which drain into the sewer, 7912–16. By moving the sewage to Barking and Crossness from London, a vacuity was created in the upper part, which the tide has a tendency to fill. The result is that this removal has created a tendency for the tidal water to bring the sewage back again. He hands in a table of capacity of the River Thames, prepared by Mr. Mansergh to which has been added the volume of fresh water entering the river, between Teddington and Southend, and between Barking and Southend, 7917–29. Referring to the table of analyses by Professor Way on the chlorine in the river (*see Q.* 7511) he points out the difference existing between the amount of chlorine in the river at spring and neap tides, 7989–92. *Hands in a table*, showing the amount of chlorine at high and low water in the river from samples taken on the flood and ebb tide between 29th October 1882, and 7th November 1882, from Teddington to London Stone, 7993–4. Hands in another table, produced from chlorine tests, showing the quantity of upper river (Teddington) water mixed with each volume of tidal (Southend) water at various places on the Thames, 7997–8, 8226–32. The conclusion he comes to is, that the capacity of the sewers being inadequate for the district, sewage is discharged into the river at higher points, which naturally lingers longer in the river, and at certain periods of the year tends very much to increase the pollution of the river, thus rendering its condition very unsatisfactory, 7999–8003. He has seen the river this year bubbling up from the effects of fermentation and black in colour, and a year or two ago it was very foul between Deptford and below Erith. In the summer of 1878 the river was most frightfully offensive throughout the same district. It was like sailing on the top of a cesspool containing diluted cesspool matter, 8004–15. It is a fact, that sewage when mixed with sea water certainly undergoes a rapid decomposition, but his tables are not fallacious, because he was careful to put in the words "sewage and river water combined" in all his tables, 8389–94. He does not consider the discharge of sewage into a tidal river, where it mixes with sea water, the safest way of disposing of it, because his experience of sewage works in sea-coast towns have proved the discharge of sewage into the sea direct, to be a most frightful nuisance, 8395–9. So, in the Thames, the accumulation of many days sewage must create a nuisance, 8398. There is no "pure" water at Barking or Crossness on account of the fresh discharge of sewage at high water just after the last discharge on the ebb has ceased only a few hours, 8401–2. Extracts read from his book on sanitary engineering on the discharge of sewage into the sea, 8400–11. To get rid of sewage by decomposition is a slow process; if you select a tidal outfall at the proper point, it is got rid of at once; but if you put it into a river, it is washed backwards and forwards, 8412–4. Four parts of pure water to one of sewage is equal to the purest effluent sewage; the only pure water coming into the river is the upland water, and it is impossible for any sea water coming up as far as the outfalls to be fresh, because the tide runs up or down only 12·6 miles, so there is an interval between them of the distance of two tides, in which no water fresh from the mouth of the river or from the uplands can enter, 8414–8. Another thing to be borne in mind is, that the sewage is discharged only upon a certain portion of the water, and not upon the whole volume going down, 8419–21. Hands in some tables marked A. and B., showing the effect of the mixing action in the River Thames when the amount of sewage has been taken as 10 and 20 parts, 11,758.

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—There is no doubt that, owing to the superior influence of the flood tide, matters of a certain specific gravity can be picked up and carried to a certain point and there dropped, and the ebb tide will not carry them down again, 7319. The parts which are heavier than the water are carried backwards and forwards, and, coming to rest at the end of each tide, are precipitated to the bottom of the river. This constant oscillation is most deleterious, especially

## Mr. BALDWIN LATHAM—*continued.*

### Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

in hot weather. The matter which is not deposited becomes more or less impure as long as the mixing goes on, 7447–8. The experiments, which were carried out by the Native Guano Company under the control of the Metropolitan Board of Works in 1872, were made for the purpose of testing the purifying result of the process and the amount of manure produced. The sewage experimented upon was stated to be 11,672,737 gallons, being $\frac{1}{3\frac{1}{4}}$rd of the average flow of the sewage discharged at Crossness, and $\frac{1}{6\,8\,6}$th of the sewage of London, 7434–39, 7875–82. By the A. B. C. process, the equivalent of 81 tons of dry material were added to the sewage, consisting of sulphate of ammonia, charcoal, and clay, with a little blood and lime occasionally, and this produced 142 tons of manure. Of this quantity, 26·45 per cent. was found to consist of water, and 104·441 tons of dry material remained. The result showed in the mixture there were 43·31 tons of solids in suspension, which is equal to 57·41 grains in a gallon. In a year it would amount to 135,096 tons in 1872, and at the present time it would amount to 197,647 tons of solid matter in suspension flowing into the river per annum, 7883–98, 8458–62. The dry matter produced by the population is 3½ ounces per head, or 138,789·5 tons a year. The difference between that and 198,000 tons of solid matter in suspension, is due to road scrapings and other foreign matter. This agrees pretty accurately with the amount stated by Messrs. Bidder, Hawksley, and Bazalgette in their Report of 1858, page 74, viz., 250 tons a day of solid matter, allowing for the increased population, 7899–7911, 8042–3, 8098–8115, 8377–88, 8463–9. The mixing action would affect everything in suspension which is capable of mixing, but it would not affect the solid matter which falls to the bed of the river. That could only reach the sea either by a sufficient velocity of the stream to carry it down, by gradually being dissolved if capable of dissolving, or else by decomposition. That which is capable of mixing would naturally reach the sea first, 7976–8. As the velocity of the flow of the sewers on the south side is greater than the velocity of the ebb tide the tendency must be for the sewage to deposit. On the north the balance is about equal. The tendency to deposit would increase as the velocity slackened, especially near the turn of the tide; and in slack places mud banks would be formed, 7979–83, 8038. This rule would not apply to deposit in sewers if discharging in a tidal river, 7984. The amount of deposit depends to a certain extent on the angle at which the sewers impinge on the river, 7984–8. The bulk of the sewage is brought to a state of comparative quiescence in the reservoirs when there is no flow into the river, and the reservoirs therefore become places of subsidence as the Metropolitan Board of Works intended they should be in times of storms, 8039–41. A certain portion of the solid matter in the river does not undergo a destructive decomposition. The quantity of mud brought down by the upland water is comparatively small and discolours the water only. The quantity of sewage introduced annually into the river is certainly not small compared with the total amount of mud in suspension, for the mud brought up by the tide is very nearly the same every day, but in the case of sewage a fresh volume is added daily, 8043–58, 8088–91. The average amount of matter washed into the river annually from the foreshore and the saltings is considerably less than the amount of sewage discharged into the river annually; it is less than a third of the quantity, 8059–65. It is quite possible that a proportion of suspended matter is beaten up in storms from the sand and mud banks at the mouth of the river and carried up by the inflowing tide at certain periods. It can, however, only be carried 12 miles. It is a very difficult thing in the Thames to decide what has been taking place from natural denudation, and what from constant dredging, 8066–7. It is utterly fallacious on the part of the Mud Inquiry Commissioners to say that the dry weather sewage contains on an average 23 grains of suspended matter per gallon. The correct quantity is 57 grains in the gallon. The difference exists in the omission on their part to consider the amount of added matter in the A. B. C. experiments, part of which went away in solution in the effluent water. This should have been deducted, 8068–87. The destructive process (referred to in Q. 8043) is the resolution of the sewage into its constituent parts. The mineral portion, such as road detritus, would be capable of forming sand in the bed

## Mr. BALDWIN LATHAM—*continued.*

### Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

of the river, and the strictly organic matter, which is no longer capable of depositing, poisons the water, and it is that which in hot weather really causes the river and mud banks to be so offensive. In the course of decomposition, certain parts of the constituents of the mud banks are given off in a gaseous form and pass into the water, 8088–97. Referring to his answer to Question 8,064, he wishes to state that the solid matter of which he was speaking with regard to the sewage, viz: the 200,000 tons a year passing into the Thames, is absolutely dry matter. But that is compared with the saltings of the river which are taken out in cubic yards, and calculated that a cubic yard in its natural state would weigh a ton. But he is now comparing dry matter with matter which contains 40 per cent. of water, so that the absolute dry matter in the saltings would be very much less than 41,417 tons, and the ratio of the dry matter of the sewage would be very much greater, and would be more than six times as much as the dry matter of the saltings, 11,758.

Effect upon Health in the neighbourhood of the Main Outfalls.—Hands in tables showing the population, births, and deaths, with the rates of births and deaths, per 1,000 at Barking, Grays, Dartford, and Gravesend from 1871 to 1881 inclusive. These comprise the towns within the registration districts as well as those named. The figures show considerable fluctuations in the death rate which are not really consonant with very healthy districts. The most unhealthy district is Dartford, which includes Erith, 7930–4, 8357–66. By dividing the births by the deaths, a more satisfactory result as to health is obtained than if the death rate alone is considered. The larger the proportion by which you can divide, the healthier is the district. The average condition of health in a district should show the births twice as numerous as the deaths, 7935–43.

Effect on Wells near the River.—He believes the discharge of sewage into the river affects the wells in the neighbourhood. In 1878 he investigated the sites chosen by the Metropolitan Board of Works for the purpose of supplying London with water from the chalk formation, one site being at Grays in Essex, 7944–50. Samples were taken from the wells at Grays and Erith which were submitted to the chemist for analysis, 7951–3. In 1878 levels were taken of the water in all the wells in the neighbourhood, and it was found that when pumping was going on at the quarries, all the water fell to the point of exhaustion, and it was also ascertained that there was a direct flow from the Thames itself to the spot chosen for the water supply, 7954–5. Pumping at the chalk quarries affects the water for miles round, and by pumping at the Grays quarry, the water at Gibbs' chalk quarry, distant one mile, is immediately lowered, 7956–8. From analyses of the water taken at Grays some time ago, the water in the wells contains 1·4 parts of chlorine per gallon, but it varies according to the state of the tide. The recent analyses show that there is an average of 23 gallons of river water mixed with 1,000 gallons of the water from the district, which tends to prove that the sewage would get into the wells. At Erith, in one instance in 1882, assuming that all the chlorine was due to the river and none due to leakage from cesspools, one-third of the water in the well had been in the river, 7959–65, 7971–5, 8016–21. The water when it contains chlorine becomes unhealthy, 7966–70. In Table 9 of the Report of the Metropolitan Board of Works Engineers, upon main drainage, dated 1858, the statement that there are several wells along the shore near low water line containing fresh water, not at all brackish, is quite correct with regard to the water in its natural state, but that condition is immediately altered directly pumping begins in the neighbourhood. Exhibits a sketch which illustrates the theory of tidal wells, 8022–4. He mentions a well at Plymouth which is absolutely dry at low water, but at high water it fills with fresh water and overflows into the tidal way. If any exhaustive pumping were going on, the tidal water would enter, 8025. The chalk in the London basin is fed from the highlands both on the north and south sides of the river, but the quantity of water varies immensely, 8026–7. He hands in a report dated 17th September 1860, by Dr. R. D. Thomson, on the water from the springs at Grays, Essex, the analysis showing 2½ grains of chloride of sodium per imperial gallon, 8028. The analyses made of the samples which witness took

MR. BALDWIN LATHAM—*continued.*

EFFECT ON WELLS NEAR THE RIVER—*continued.*

showed 13·6 parts per 100,000 parts of chlorine at high water, which in his opinion is a most unusual thing in fair chalk water. Dr. Tidy who made the analysis will produce it, and give evidence on the subject as well, 8029–34. He has collected statistics on chalk from the North and South Downs as well as from Yorkshire, and his experience shows that except in wells near the sea (where a greater quantity will be found) so large a proportion of chlorine in inland wells, viz., 13 in 100,000 parts, is enormous. The analysis was only made for his own instruction, not to ascertain whether there was evidence of sewage contamination, 8035–7, 8116. The wells referred to at page 104, Sixth Report, Rivers Pollution Commission, 1874, are totally different to the ordinary chalk water wells, as the chalk is overlaid by other geological formations, 8117–24. The wells further inland than Grays show that they have not the same amount of chlorine in them, nor are they influenced in the same way. The standard amount of chlorine in distant wells near Erith is 1·4 per 100,000, 8494.

DISCHARGE FROM THE STORM OVERFLOW OUTLETS.—If the sewers are not large enough to take the sewage and quantity of rain which they were designed to take for a greater number of days or periods than was contemplated, then the overflows must act, and whatever brings these overflows into operation, must lead to a greater degree of pollution of the river in the higher parts, because it takes much longer for the sewage to get out of the river, 7686. On the south side of the river the ratio of the flow in time of rain to the mean flow is 2·76 to 1, so that if the rain is double the sewage it would fill the sewers, and upon the average every time it rained in London the sewers must overflow at some point or another, 7824–9, 8129–33. Has never taken any samples when a discharge was going on, but he believes samples have been taken and analysed. The discharge from the outlets is much more filthy and much more concentrated sewage than that which is discharged at the main outfalls. More overflows are now being constructed, the effect of which will be to bring the sewage and rainfall combined to a greater extent into the upper parts of the river, 8498–9.

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER.—Some months ago he was requested by the City solicitor to investigate the discharge of sewage into the Thames, and in this he was assisted by Mr. Mansergh and Mr. More as engineers, and Mr. Birch was engaged to look after the float experiments, 7199–201. To ascertain the horizontal range of oscillation of the tides near the northern outfall, a series of floats, (similar to the one exhibited to the Commission) were put into the Thames, and their motion watched day and night by men in small boats, superintended by Mr. Birch and his staff from a steamer, 7202–3, 8422–9. The dimensions of the floats are 12½ feet in length, and 11½ inches in diameter. In shape they are octagonal in order to offer as nearly as possible the same surface to the water if they revolved; they would stand vertically in the water, and the minimum and maximum heights of the floats out of the water are 6 inches and a little less than a foot respectively. On an average they were immersed 12 feet. Salt water would raise them a little on account of its additional buoyancy, 7204–10. Use has been made of the existing recording gauges on the Thames, and others have been erected, especially in the lower part where it was most important to carry on observations with regard to the rise and fall of the tide, 7211. The total drainage area of the Thames is 5,162 square miles; and the Thames, and all the tributaries which it was possible to gauge, have been gauged, because it was of importance to ascertain the volume of the water coming into the river at all points, 7212–14. The drainage area of 5,162 square miles includes the Thames and its tributaries from its source to its tributaries from its source to its mouth (*see* Mr. Symons' plan), with an average breadth of 50 miles. The length of the channel of the Thames is 201 miles. About 500 square miles are due to the drainage area of the River Lea, 7215–24. The quantity of water in th river below the outfalls is of great importance fo the purposes of his deductions, 7225. The quantity of water flowing from the draining area has been gauged with the exception of 284 square miles, operations having been carried on at 50 different points. The quantity of water flowing from the 284 miles has been arrived at by taking a similar area below Teddington Lock, and making calculations therefrom, the

MR. BALDWIN LATHAM—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

result is shown in the table of gaugings. The ungauged portion represents one-eighteenth part of the whole drainage area, 7226–8. The statistics contained in his Report are the results of his own actual inspection and supervision, and from the observation of those who watched the floats; on many occasions he personally observed the floats, though obviously he could not always do so, 7229–36, 8422–9, 8500. The distance from the northern outfall to Crossness is a mile and a half. From the northern outfall to Erith Pier is five miles. From the same outfall to the Town Pier, Gravesend, is fourteen miles and three quarters, and from the same point to Cliffe Creek is eighteen miles and three quarters. The whole of the river has been very carefully surveyed with the view to arrive at the capacity of the river from the area of the cross-sections, and he has used these sections in making certain calculation, 7237–42. The sewage when turned out from the outfall flows down with the tide to a certain point, and is brought back again by the next tide to a certain other point up the river. This process of oscillation would go on for a longer period than one "lunation" (that is, 14 days, 7292), until it is dispersed and gradually driven out of the river by the fresh upland water, 7243–5. The "mixing action" has, however, a much more powerful influence on the sewage than the actual displacement. The sewage flows into the tide, which, as it goes down comes into a larger area of water, which is mixed with salt water. From the fact of its having flowed into a larger volume of water, it is returned more diluted than if it had been in a parallel channel of small size all the time. The mixing takes place also by the influx of fresh water. If there was no mixing action, the water from one range of the tide would be found to be fresh at the mouth of the river, whereas sea salt has been found in the river at Chiswick, 7246–52. The results of his observations on the distribution of sewage, as shown by the "float" experiments, are given on the diagrams he hands in (*see Appendices S. and T.*), 7254, 7995–7, 8134–40, 8431–49, The experiments began on the 17th September, and the first float was put into the centre of the river at high water opposite the northern outfall. It drifted down 15·84 miles with the tide (which was just after spring tides). After seven days of drifting it reached a point just opposite Higham Bridge. It drifted 2·08 miles above the northern outfall on the 29th September. On that day it was a spring tide, when the water flows up more rapidly than on a neap tide, 7253–67, 8169–72. The float was lost in a fog on the 13th October, but was started again the same day in the same position it held, with No. 4 float, as when lost. A hitch in the management of a float is shown on the diagram by a black dot. The observations continued until the 24th October, when they were stopped by the unsettled state of the weather, 7268–73. During the 45 days this float was in the water it only progressed 2·20 miles down the river from its starting point. Taking two complete lunations, the progress was only two miles, and in 26 days, when there was no break, the progress was only 1·76 miles below the northern outfall, 7274–6. As regards No. 2 float, which was in from 17th September to 19th October, a doubt as to its whereabouts is shown on the diagram by a dotted line. It was put in at half tide, and at the end of 31 days it had advanced 1·3 miles up the river. When the floats grounded the men had instructions to haul them straight out into the stream, 7277–95. No. 3 float was in for 43 days, and was put in at low water; at the end of that time it had descended 13·80 miles down the river. These three floats were all put in just when the tides were taking off after spring tides, 7296–300. Floats Nos. 4, 5, and 6 were put in at neap tides, at high water, half tide, and low water respectively, and their movements are accurately recorded on the diagrams, 7301–2. Upon afternoon tides the range is greater than it is upon morning tides, and this fact will show that the floats could not have been anchored during the night, 7326, 8428–31. The last diagram but one shows the phases of the moon, the direction and velocity of the wind, the amount and condition of the tide, spring or neap, and the quantity of water flowing every day in cubic feet over Teddington Weir. By multiplying the number of cubic feet per minute by nine, and add three cyphers, it gives the number of gallons in 24 hours, but for his calculations he has used a multiplier of 6¼, 7304–9. The last diagram refers to some experiments made with regard to the mixing

Mr. BALDWIN LATHAM—*continued.*

Distribution of the Sewage in the River by the various Motions of the Water—*continued.*

action, 7303. They were made with a view to apply practically the results theoretically arrived at from the amount of chlorine found at various points, 7311–2*a*. At certain phases of the tide, when more water is coming into the river, that is, when the tides are making, the tendency is for things to drift higher up. At other times the tendency is for more water to flow out and things drift down, but it may be modified by the wind or the quantity of water coming down from Teddington and the tributaries of the Thames, 7313–8. The ebb tides are much longer than the flood tides in their apparent flow, and, taking the relative velocity of each, it will be found that the velocity of the ebb is very much smaller than that of the flood. The velocity of the flood is 192·2 feet per minute, while at the ebb it is 167·6 feet per minute. The flood runs up for 5½ hours, and the ebb runs down for seven hours at Westminster. If there be a tendency to a greater flow of tidal water along the bed of the river, as is shown by experiment, by the greater amount of chlorine, it has then a tendency to accelerate the motion of a float up the river, 7321–3. A float was kept continuously going down with the ebb from Teddington to Southend, and a corresponding float was always coming up. Samples of the water were taken at various points and at similar states of the tide, on the surface and at half the depth of the river, which were submitted to chemists for the purpose of ascertaining the amount of chlorine they contained. Owing to the powerful stream of upland water coming down on the 4th November, the float put in on that day at Yantlet Creek was not able to work up the stream. On the 3rd November the volume of water coming over Teddington Weir was 711,000 cubic feet per minute, and on the following day it was 627,547 cubic feet per minute. The lowest volume has been 74,279 cubic feet, 7324–7. It takes about three days to work a float from Yantlet Creek to the Commercial Docks, as the greatest amount of tidal water is found there, but higher up the progress is much slower. At points where the upland water is large, there is a greater flow downwards, and the more tidal water the river contains in proportion to upland water, the longer sewage will oscillate, but the more it mixes, 7328–30. On his own diagram he has put figures showing the amount of chlorine in the various samples of water, which are taken from the analyses of Professor Way, 7331–3. Has prepared a table (which he hands in) showing the effect of the mixing action in the River Thames at high and low water. The results are obtained by taking sewage as containing 10, river water 1·7, and sea water 1,961 parts of chlorine in 100,000 parts. The number of days is calculated from the gaugings of the total flow of the River Thames, on each day. In this case all the upland water is assumed to enter the river at Teddington. This table shows the result of the experiments and the effect of the mixing after his calculations upon the 14th and 22nd of September and the 30th November 1882. The places to which the various mixing experiments apply are given; at Teddington chlorine was found in the water, which was due to the river water and sewage, 7334–44, 8291–303. The water as it comes over Teddington Weir has chlorine in it, and the standard of 1·7 is assumed to be the initial quantity due to the river, and is the mean of the whole, 7345–8. The calculations have been very carefully made with reference to the quantity of chlorine which is due to the presence of sewage or sea water, because it has been taken for granted that wherever sea water is carried past the outfalls, there sewage might be carried past, 7349. The proportion of chlorine in sewage is nothing like the amount in sea-water, but whenever chlorine is found, the inference is that sea-water has got up to that place, 7350–1, 7354. The calculation that if a particle of sewage were put in at Teddington it would take 1·71 days to reach Cniswick, is based upon the capacity of the section of the river and the total quantity of water coming down the river. The tables were compiled in a hurry, and on the assumption that water only came into the river at Teddington, whereas it comes in at various points. This has now been corrected *and an amended table is handed in*, 7360–2, 7369. A particle of sewage would take 31 days to get from Barking to Southend on spring tides, 7364–6. On the 22nd September there was about 50 per cent. more upland water in the river than on the 14th September, assuming 157,745 cubic feet of water to be coming down per minute on a neap tide, 7367–73. On the 30th of November the river was in flood, and the tide was neap tide. The total quantity of water on that day coming into the river is



Mr. BALDWIN LATHAM—*continued.*

Distribution of the Sewage in the River by the various Motions of the Water—*continued.*

estimated at 557,000 cubic feet per minute (treated as all coming from Teddington), 7376–9. Sewage at high water would take 27½ days to go from Barking to Southend on a neap tide and nearly the same time at low water. With the river in flood, the time would be 14½ days at high water, and about 13 days at low water, 7374–5, 7380–1. He had considered the question of mixing before the chlorine experiments were made, and the tests were taken to see whether the original samples would confirm the view as to the change going on through the river, 7382. That there is less area occupied by sewage and river water where there are two outfalls than where there is only one, is due to the fact that there is a constriction in the cross-section of the channel at that point. The area of the cross-section is arrived at by putting an imaginary division, one foot in width, across the river and finding the superficial area of it, 7383–6, 7392–3, 8291–2. Judging from the quantity of chlorine at Barking, out of a total of 65,791 square feet, there are 40,852 square feet of sewage and river water combined. At Crossness there is more sewage and more sea-water, 7387–91. Taking the average condition of the river, the quantity of fresh water coming in is about 30 cubic feet per minute per square mile of drainage area, which would represent 157,000 cubic feet a minute of which 122,000 comes over the weir. In dry weather it would go down to 12 cubic feet per minute per square mile, 7394–403. There is nothing in the table which would represent a drought period, 7404. In a maximum flood, the quantity would be 360 cubic feet per minute per square mile, or 1,304,000 cubic feet on the whole area, of which 1,053,000 would come over Teddington weir, 7405–8. In a dry period sewage would take a much longer time than is given in the table to be carried from Barking out to sea, but without an experiment it is impossible to know the exact time for certain. In flood time it would probably be carried out in a week, 7409–13. Low water at Southend on the average of tides was higher, between September and November 1882, by 1·87 feet than at Deptford, by 1·06 feet than at Gravesend, by 1·52 feet than at Erith, and at high water it was, during the same period, 2·06 feet lower than high water at Deptford, taking it from the mean sea level, 7424–9 This shows, as a curious fact, that the river in flowing down does not obey the ordinary law of water, moving down hill because it moves up hill. It is moving by tidal impulse, 7431–3. The reservoirs having been constructed on such a level that they cannot be emptied ordinarily until three hours after high water, the first part of the sewage discharged flows down 12 miles, while the last part would only flow six miles, and the next tide would bring the last outflow six miles above the outfall, it having been discharged three hours after the first. The ebb goes at the rate of two miles an hour, so there would be a section of six miles of river occupied by sewage, and the next section would have no sewage in it. The Metropolitan Board of Works have always taken 12 miles as the range, but 12·6 miles is the average range of all his experiments. The level of the floor of the reservoir is 2·75 above the ordnance datum, so the discharge cannot begin until three hours after high water, 7440–6. On some occasions deep floats were used, and at other times surface floats. It was found that in ascending the river the surface floats moved with less velocity than the deep floats, but in descending the river, the reverse was the case (*vide* page 37 of Mr. Latham's Report), 7460–3. The times of ebb and flow vary, the flood being shorter than the ebb throughout the river. They are nearer in the lower part of the river, and more unequal in the upper part of the river. For example, at Teddington there are only two hours of flood and 10 hours of ebb, while at Southend there are 6 h. 3 m. of flood and 6 h. 22 m. of ebb. There is also an increased range of tides in the Thames to what there was formerly. It is due in a great measure to the gradual deepening of the river from dredging operations, which tends to accelerate the flow of the tidal wave and make it greater, 7464–74, 8470–2, 8495–7. From the observations taken during a period of three months the mean tide level has been deduced. The mean tide is half way between high and low water.

The mean tide level is above the ordnance datum:—

| | |
|---|---|
| At Deptford | 1·98 feet. |
| At Teddington Lock | 11·00 ,, |
| At Erith Pier Pier | 1·96 ,, |
| At Gravesend Pier | 1·94 ,, |
| At Southend Pier | 1·89 ,, |

MR. BALDWIN LATHAM—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

The mean at the outfalls would be between 1·96 and 1·98.

The Metropolitan Board of Works take their mean level to be 1·5 half tide. It also shows the mean high water to be 11 feet above ordnance datum and the mean low water to be 7 feet below. This shows that 1·5 is incorrect and the mean should be 2 feet exactly, 7475–84. The average range of the tides as ascertained by the float experiments is 12·6 miles on the flood and 12·64 miles on the ebb. As the distance from the Nore to the outfall is 36 miles, the sea water would travel 12 miles, and there would be an intermediate 12 miles in which no sea water at one end and no fresh water at the other end would enter. Sewage would be carried upon an average 12·6 miles, 7485–93. The tidal wave acts by impulse on the body of water at the mouth of the river and propels it up the river. If there were no mixing action going on, the water at the lower end of the river at low water would be identical with the water 12·6 miles higher up at high water. Mixing action is principally due to currents, while the ebb is running down, the flood is running up the sides of the river, 7494–5. Without any mixing action there would be a body of water constantly oscillating in the Thames, and it would take 300 tides before anything put in at Crossness would travel 12 miles, 7495–500. Salt water advances up the river as the upland water decreases, so in a dry season it gets up higher than in a wet season, 7500*a*–3. The tidal wave moves with a velocity equal to that which a solid body would acquire in falling a distance equal to half the depth of the channel. In a rectangular channel, the velocity is equal to the square root of half the depth. In the Thames from Southend upwards, the velocity of travel of the tidal wave is fifteen times as great as that of the ordinary flow of the tidal current, 7504–5. In the spring and autumn the period when the upland water exceeds the average is longer than when it is below the average. There are exceptions sometimes during summer floods, 7506–9. The difference between high water at the Nore and London Bridge is one hour and a half, and between London Bridge and Teddington is one hour and 20 minutes. It is a difficult matter, however, to say exactly when it is actually high water at Teddington, because the top of the tidal wave only is recorded, 8140–55. As morning tides he classes any tide of which the largest part is between 12 midnight and 12 noon. As afternoon tides he classes those tides the largest part of which is between 12 noon and 12 midnight. So that high water at 2.30 p.m. would be a morning tide, and high water at 4 p.m. would be an afternoon tide, 8159–68, 8473. At the time of the "float" experiments, the range of the tides was greater in the afternoon than in the morning, which explains the fact that the floats went up further on the afternoon tides than they went down. There is a diurnal difference in the period of the tide which is greater in the afternoon. It would occur upon the flood tide only, 8172–4. The diurnal fluctuation in the flow of the tides affects the afternoon tides in the winter, and the morning tides in the summer. Whatever varies the height of the tide must also vary the velocity of flow. When the tides rise higher they also fall lower. There is also a greater difference of proportionate velocity between the flood and ebb tide, 8175–89, 8430–51. Mr. Latham was here cross-examined by Mr. Bidder at some length on the float experiments, who handed in diagrams representing the course taken by the floats, and challenged Mr. Latham's diagrams as being absolutely worthless. Mr. Latham explained that the diagrams he himself handed in, showed the true course of the floats as they were all in different parts of the river, some going down, while others were going up. The amount of land water coming down would also affect their progress according to their position in the river, as in the lower part of the river it has less effect than in the higher and narrower part, 8190–9, 8234–90. Taking the mean effect all the year round, and if there were no mixing action, the sewage ought to pass Crossness at the rate of three-quarters of a mile a day, but by reason of the mixing action it goes much quicker, 8200–8. The floats have nothing whatever to do with the question of displacement. One simply shows the oscillation of the tides, and the other shows what is the natural displacement in the river by the quantity of water coming down. Wherever the floats go, the sewage may go too. They have nothing to do with the ordinary displacement, 8209–23, 8452–6. Hands in a further set of diagrams. *See* Appendix A.D., illustrating the progress of the floats. The discrepancies in their progress to which Mr. Bidder called attention at the last meeting are explained partly by the influence of the wind acting on the floats in different parts of the river, especially in the crooked part between Blackwall and Woolwich. The disturbed state of the weather would have a tendency to carry the floats into slack water, and in the case of two floats traversing the same part of the river, one might be in slack water though not aground, while the other might be in the full force of the stream, 8233–84, 8443–9. He read the instructions to the men in charge of the floats, 8285–90. Sewage water contains 10 parts of chlorine in 100,000, and not 20 parts. Assuming, however, that it did, the tables he handed in would not be vitiated, they would merely require to be modified, but the difference between 10 and 20 parts is very slight, as the volume of the sewage is very much smaller than of the tidal water, 8304–14, 8474–7. He corrects an error, which was unavoidable, with regard to the length of the ebb and flood tide at Teddington. It should be 12 hours 25 minutes instead of 12 hours 13 minutes (*see* Q. 7466), 8470–2. He finds, taking the number of days required for the sewage to pass out of the river, that it only makes a difference, in some instances, in the second place, of decimals. Upon the 14th of September, at high water, taking the whole distance from Deptford to Southend, with 10 parts it would be 41·38 days, and with 20 parts it would be 41·39 days. And the same at low water you have a result of 40·97 which becomes 40·99, and so with regard to all the rest of the days, 11,758.

MR. BALDWIN LATHAM—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

POPULATION TO BE PROVIDED FOR.—Has made some calculations for the purpose of showing that the population has outgrown the accommodation which the sewers were intended to provide for, 7579. The population provided for in the north in 1858 was 2,353,900, and in the south, 1,094,600, and the western district, 553,900. This was estimated to cover the increase of population in the future. From the census of 1881, the population in the north was 2,548.999, and in the south, 1,283,448, which exceeds the estimated increased population taken in 1858 by 443,000; or nearly half a million more in the metropolis and the districts outside draining into it than the sewers were contemplated to take, 7616–39, 7647. Hands in a table which gives the population within the limits of the Registrar-General's district on the north and south of the metropolis between 1871 and 1881, and another table showing, (*a.*) the estimated prospective population from 1882 to 1901; (*b.*) the population of northern and southern London, metropolitan divisions interpolated for the 30th June of each year; and (*c.*) the prospective population at the same rate of increase until 1901, 7642, 8501. The Registrar-General's district is known as the Bills of Mortality district, and its limits correspond more nearly with the district sewered than the Metropolitan Board's district population itself does, 7642–7. Taking the increase in the population up to the present time as half a million in 20 years' time it will amount to 5,360,000, 7648–50. The rateable value has increased from 11,000,000*l.* in 1856, to 27,000,000*l.* in 1882, 7651–2.

RAINFALL TO BE PROVIDED FOR.—Has made some calculations which tend to show that the amount of rainfall which the sewers can take is really below what actually gets into them, 7580. The amount of rainfall to be dealt with is on the north 28,500,000 cubic feet, and in the south 17,250,000 in the day. The Report of 31st December 1874 also stated that a quarter of an inch of rain flowing off the area is estimated as flowing off uniformly throughout the 24 hours, or $\frac{1}{100}$th part of an inch in one hour during the maximum period of the flow of the sewage, 7652–6. The maximum flow of sewage has been calculated to be half the total volume flowing off in six hours, and the other half in the remaining 18 hours, 7657–8. One quarter of an inch a mile represents 580,800 cubic feet, and if this is divided into 28,500,000 (the quantity of rain the sewers are to carry) the area would be 49·07 square miles. Treating the south in the same way, the area would be 29·7 square miles, 7659–63. The provision made for the south is for a much smaller district than should have been provided for, but only $\frac{1}{3}$ instead of $\frac{1}{4}$ an inch of rain was taken as falling in the south (*vide* Sir Joseph Bazalgette's Report of 13th April 1856), 7664–70, 7702. The

MR. BALDWIN LATHAM—*continued.*

RAINFALL TO BE PROVIDED FOR—*continued.*

higher the district the more rain falls on it, and he would have thought it more necessary to make the larger provision for it. In a thinly populated district a smaller quantity of rain would dilute the sewage to a given point, while in a thickly populated district it would require a larger amount of rainfall to dilute it to the same extent, 7703. If the district is completely built over, then all the rain goes into the sewers, 7704–5. The conclusion drawn from this shows that a very much larger quantity of water and sewage per square mile in depth over the area is discharged at Crossness than at Barking. Out of 29·28 inches of rain falling in the south in 1875, 18·3 inches of that quantity flowed off either by flowing into the sewers or by percolation, while on the north it was only four-tenths of an inch that actually flowed off. The difference between these figures, after deducting what had been evaporated, must have come into the river at a higher point than the outfalls. The water which ought to have got out at Barking must have been liberated by the storms overflows, or else the southern sewers must have tapped the underground springs. His reason for thinking that the sewage which should go to Barking and does not, is on account of the gaugings taken some years ago at Crossness, and which were put in at length in the Mud Inquiry, 7706–9. During a dry season, as in July 1876, when these gauging observations were taken on the 12th July, no rain having fallen, it showed conclusively that out of 50 gallons per head discharged at Crossness, 30 gallons were due to sewage proper, and 20 gallons to leakage, and consequently there must be a number of days upon which there must be an overflow, 7710–8. It has been calculated that if the rain happened to come when there was the maximum period of flow the sewers could only carry away one-hundredth part of an inch per hour. The evidence given in Sir J. Bazalgette's report says, that one-quarter of an inch of rain fell only on 12½ days; but this is erroneous. Witness has taken observations at Croydon of every drop of rain that falls, and the rate at which it falls; and has an apparatus showing to what extent the sewers are affected by the rainfall. But at Croydon the conditions are more favourable, nor do the sewers fluctuate in flow so much as in London, 7762–3. In Sir J. Bazalgette's report to Parliament in 853 it was proposed by the company to provide for one-quarter of an inch of rain, but Sir J. Bazalgette said in evidence that if no more was admitted than that, the sewers would still overflow on 80 to 100 days all along the river (*see Q.Q.* 2536, 2558, and *Q.Q.* 520, 521, evidence given before the Select Committee on the Great London Drainage Bill), 7764–71. On those days the whole of the sewage mixing with the rain would not go into the river, but he is unable to say how much of it would overflow. The sewers in the higher districts were only calculated to take one two-hundredth part of an inch per hour, so whenever rain falls to a depth of one-hundredth of an inch, and there is the maximum flow of sewage flowing, there must be an overflow, but the rainfall would be very much in excess of the sewage, 7772–8. He has designed a registering rain-gauge (which has been in use since 1879), that records the time of day, the quantity, and the rate at which the rain falls. He gauged the Croydon sewers for the purpose of ascertaining the amount of spring water which leaked into the sewers whilst he carried on his rainfall observations, and from these he was able to ascertain how much any particular fall of rain affects the fluctuations in the Croydon sewers, and he hands in diagrams giving details of all his observations (*see* Appendix A., C.), 7787. The degree of fluctuation caused by rain depends on whether the maximum or minimum quantity of sewage is flowing through the sewer. The result of his observations, so far as it relates to the actual fall of rain would be a fair parallel to London, 7788–800. In 1879 the average rainfall per hour of ·066 on 132 days increased the mean flow in the Croydon sewers by 4·9 times. In 1880 the average per hour of ·075 on 135 days increased the mean flow 3·78 times, and that made it about four times as much as it was before. Had the rain fallen at that rate for 24 hours, it would have been four times the quantity of sewage, 7801–8. The Croydon sewage is more diluted with water than the London sewage on the north. On the south it is much the same as at Croydon. The quantity of water supplied at Croydon her head is 50 gallons, therefore the quantity of sewage per head of the population is greater in dry weather than in London. The

MR. BALDWIN LATHAM—*continued.*

RAINFALL TO BE PROVIDED FOR—*continued.*

average of all his observations show that if ·065 of an inch of rain falls, the mean rate of flow in the sewers is increased 4·16 times, 7809–11. The Croydon sewers are capable of carrying this off, as they have no overflow except by percolation, and all this time there must have been an overflow in London, 7812–4. There are times when the sewers have carried off twelve times the mean flow, 7815–7. He has no evidence to show how often in the year the metropolitan sewers overflow into the Thames, 7818–21. The soil of Croydon consists of chalk, gravel, London clay in some parts, and in others the Woolwich and London beds. The population is not so dense as in London, and consists of 60,000 people. The area to which he refers is three square miles, 7822–3. Reads an extract from his work on "Sanitary Engineering," with reference to the operation of rainfall on the London sewers, 8492-3.

CAPACITY OF THE DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT; INFLUENCE OF THIS ON THE STORM DISCHARGES.—Occasionally sewage can be discharged from the top of the flood until about three hours afterwards. At times the tide drops so rapidly that the discharge runs for two and a half and two hours only. The reservoirs will only hold the quantity of sewage which the sewers are capable of bringing down in two to three hours, and when the sewers are running full for a longer period, the sewage must overflow into the river, 7451–2. The pumping station at Grosvenor Road is used to pump the sewage into the low-level sewer, whence it is taken by gravitation to Abbey Mills and pumped into the Barking sewer, 7453–5. Knows that it is discharged direct into the Thames at times, because it was originally intended to deodorise the western district sewage, and it was afterwards decided to carry it to Barking. When, therefore, the sewers are taking the quantity they were calculated to take at the outset, the surplus must be discharged elsewhere. Has seen the sewage running into the river day after day at Grosvenor Road, 7456-9. The figures relating to the area drained by the sewers of the metropolis have been taken from the Report of the Metropolitan Board of Works, dated 31st December 1874, 7581. The area draining into the northern high-level sewer is 10 square miles, into the middle-level sewer is 17½ square miles, into the low-level sewer 11 miles, and into the western district 14½ miles, making a total of 53 square miles. On the south the area draining into the high-level sewer is 20 square miles, and into the low-level sewer 20 square miles, making a total of 40 square miles, or a gross total of 93 square miles. At the "Mud Inquiry" totals were given as 51 and 43 square miles respectively on the north and south, but his figures he has checked by the ordnance map, 7581-5.

The following is the division of the area within the jurisdiction of the Metropolitan Board of Works:—

| | | |
|---|---|---|
| On the north— | | |
| Land in Middlesex | 49·19 | square miles. |
| Land in Kent | ·64 | ,, ,, |
| Water and Foreshore in Middlesex | 1·45 | ,, ,, |
| Water and Foreshore in Kent | ·40 | ,, ,, |
| Total | 51 68 | ,, ,, |
| On the south— | | |
| Land in Surrey | 37·34 | square miles. |
| Land in Kent | 30·70 | ,, ,, |
| Water and Foreshore in Surrey | ·99 | ,, ,, |
| Water and Foreshore in Kent | 1·39 | ,, ,, |
| Total | 70·42 | ,, ,, |

Making a grand total of 123·1 square miles.

This agrees very nearly with the Registrar General's Returns and the reports of the Metropolitan Board of Works. The difference between the amount drained and the area under their jurisdiction, viz., 24½ square miles of land, is situated principally on the south side of the river, 7586–95. The natural streams which have their source outside the metropolitan district, and which drain into it, affect the question, as the rain which flows down the stream has to be conveyed through the sewers, and adds materially to what is naturally taken by the sewers and the rainfall in the

MR. BALDWIN LATHAM—*continued.*

CAPACITY OF THE DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT; INFLUENCE OF THIS ON THE STORM DISCHARGES—*continued.*

district not included in the area of the metropolis, consisting altogether of 8·43 square miles on both sides of the river, has to pass into the sewers, 7596–601. Then in addition there are districts, such as Hornsey, Acton, Croydon, and Beckenham, which discharge their sewage as well as their rainfall into the metropolitan sewers, although this was not contemplated formerly. Rainfall was only intended to go in, but now a portion of the sewage of these places goes in, 7602–15. The Board in their calculation take six hours for the maximum flow, while the gauging of the sewers, published by the Government referees in their report in 1857, showed that half of it flowed off in eight hours instead of six. Recent experiments, however, show that half of the whole volume of sewage flows off in nine hours. The calculations are based on the southern outfall. Of the northern outfall he knows nothing, 7671–4. The sewage is perpetually coming into the sewers during the 24 hours, and it takes considerably longer for the sewage from a distance to reach the outfall than for that closer at hand. This tends to equalise the flow during the daytime. Taking the gaugings in the Mud Inquiry it is equal to deferring the sewage on the south side 11 hours. In other words, it takes the sewage from the remote districts 11 hours to reach the outfalls, while the sewage of other districts close to takes no great length of time. The minimum flow would be at about 6 a.m., and the maximum flow at 6 p.m., 7674–9. He hands in a table, which he has compiled, showing the total volume of sewage flowing in gallons or feet in the day, which if multiplied by the decimal given and divided by 100 will show the quantity of sewage flowing per minute at any hour of the day in the district. The decimal to be used for the mean quantity per minute = ·0695. This would apply all over the country to sewers where there is no leakage, 7680–1. During the maximum flow there is less room for the rainfall, 7682. By the sewage being deferred there is really more room in the sewers than had been calculated, that is to say, during what would otherwise have been the maximum period, so that if the sewage had to come down in six hours instead of nine hours, they would have been running fuller, 7682–5. The sewage discharged both at Barking at Crossness is composed partly of rain and partly of sewage proper. He has analysed the quantities which are shown in the table he hands in. The particulars go from 1875 up to the present time. He also hands in tables showing the amount of sewage flowing off at both the outfalls yearly, daily, and the quantity of sewage per head per day in gallons. These figures he obtained from the Metropolitan Board of Works, 7687–91. He has obtained the quantity of water supplied on both sides of the river by the water companies, and by deducting that from the total quantity of sewage he gets the amount of water due to rain and other causes, 7692–6. A considerable amount of water gets into the sewers from leakage and from the subsoil, which accounts for the difference of quantity per head discharged daily on the north and south sides of the river, 7697–700. Notwithstanding that on the south there is a smaller area and a smaller population to deal with, yet there is a considerably larger quantity of rain flowing off than on the north side, 7701–2. To arrive at the estimate of 30 gallons of sewage proper per head, the quantity of water supplied by the companies was ascertained, the number of houses and population given by the census returns were taken and divided one into the other giving an average 8·27 persons in a house on the north, and 7·09 persons in the south, and then dividing the quantity of water supplied by the number of persons in a house upon the north and south, the volume of water supplied per head was 30·4 gallons and 32·5 gallons respectively, which agrees with the Board's estimate of five cubic feet or 31·25 gallons per head, 7719–32, 8501. Practically 50 gallons per head, estimated on the actual population of the southern side flows off, though the actual water supplied is only 30 gallons per head. It is not necessary that this should be leakage into the Metropolitan Board of Works sewer, it may be leakage into the local district sewers, but there is the fact, 7733–5. The last table he has put in shows that the water supply on the north side gives rather over 30 gallons per head, and that the sewage and rainfall combined has not been much more than the actual water supply. In some years, in 1875 for

MR. BALDWIN LATHAM—*continued.*

CAPACITY OF THE DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT; INFLUENCE OF THIS ON THE STORM DISCHARGES—*continued.*

instance, the actual volume shown as flowing off at Barking is even less than the estimated volume of sewage, if you take it at 31·25 gallons per head. The amount that flowed off at Barking is below what was found to be a correct estimate of the sewage per head. No rainfall flowed off at Barking although 29 inches of rain fell that year. It got into the Thames by some other means, probably by the storm overflows, 7736–44. In 1876 the quantity per head is a shade more, but though there is a little less rainfall, the quantity flowing away on the north is a little more, though on the south it is a little less. It is difficult to arrive at the amount of sewage and the amount of rain flowing off separately without actual gaugings, because part of the rainfall evaporates, 7745–8. It was originally intended to treat the western area separately, but the consequence is that if the sewers are assumed to be conveying their normal quantity of sewage and rainfall, the whole of the sewage of the western district must be flowing out at a higher point as it cannot get to any point below Abbey Mills. The northern sewers are not large enough to take it, 7749–50. At page 21 of Sir J. Bazalgette's report of 22nd May 1856, it is stated that if the western district sewage is to be taken to Barking, the reservoir must hold 9,000,000 cubic feet instead of 7,000,000 cubic feet. It has been reported to contain upon one occasion 39,000,000 gallons or 6,240,000 cubic feet. In the Thames Mud Inquiry its capacity is given as 35,000,000 gallons. In the Parliamentary Report of 31st December 1873, at page 72, it is stated that in order to make provision for the sewage of the western district, the low level sewer had to be increased in size all the way to Abbey Mills beyond what it was proposed to be, and this was done, from 9 ft. to 10 ft. 3 in. in diameter. The capacity of the outfall sewer and of the Barking reservoir were not increased as reported to be necessary. Various other works were recommended, amongst them to drain the western sewage into Hammersmith Creek, and to form a covered reservoir and deodorize the western area sewage at Fulham Fields. Neither of these courses were carried out, and it is quite clear from the reports to Parliament that the northern outfall sewer was not intended to deal with the sewage of the western area, and that after it was partly completed, it was decided to take the western sewage there, for which the sewer was enlarged, but not the reservoir, 7751, 8125–6. The three outfall sewers all meet at Abbey Mills, and there are some branches which come into the northern high level sewer. The outfall sewers consist of three sewers 9 feet by 9, which are capable of discharging 33,000 cubic feet of sewage per minute, which is rather more than was stated at the Mud Inquiry. Then two 9 feet sewers which come into the reservoir have a capacity of discharging 22,000 cubic feet per minute, and the 10 feet 3 low level sewers can discharge 15,000 cubic feet a minute making 37,000 cubic feet coming in, while only 33,000 cubic feet can go out. The difference is equal to 36,000,000 gallons a day. There being more sewage in the sewers than can be discharged at the outfalls, it must find its way out at a higher point, 7752–5, 7778–86. On the south the sewer is capable of discharging 20,000 cubic feet a minute, and there is but one outfall. Taking the ordinary sewage to be eight cubic feet per head during the nine hours of maximum flow instead of six, it gives 8,955·5 cubic feet per minute of sewage. Add one quarter of an inch of rain flowing off 20 miles, and one eighth of an inch off another 20 miles, they equal together 12.075 cubic feet, which gives with the sewage a total of 21,660·5 cubic feet. The difference between this and the amount actually discharged, shows a deficiency of about 15,000,000 gallons a day. This proves conclusively that the sewers could never have carried off the quantity for which they were designed. Then rain coming in from the outside districts occupies the sewers to the exclusion of water coming in from the metropolis, so until some of that flows away by the storm overflows the sewers are gorged, 7756–60. The sewers on the south side are not competent to deal with the quantity of sewage which actually comes down, for in the tidal period of 12½ hours they do more than fill. With a population of 1,200,000 people, representing about 10,000,000 cubic feet of sewage a day, and assuming that half the total sewage flows off in nine hours, it is quite clear that a reservoir which only holds 4,000,000 cubic feet cannot hold 10 hours sewage. If,

## Mr. BALDWIN LATHAM—*continued.*

Capacity of the Drainage System as compared with the Demands upon it; Influence of this on the Storm Discharges—*continued.*

however, you increase the time of discharge and limit the period of storage, you can make the reservoir hold anything you like, 7830–2, 8336–56. The conclusion he has come to is, that on both sides of the river the reservoirs are very much too small, but immeasurably so on the north side; and all the sewage which cannot be provided for must be let out into the river at one place or another regardless of the tide, as the reservoir on the north would, if it held 39,000,000 gallons, only hold what the three sewers running full would bring down in 2·8 hours, and on the south they would fill in 3·5 hours. On the south in nine hours one half the sewage would flow into the reservoir, and more than fill it; and no doubt the sluices are opened to let it run out before the proper time, 7833–47, 8490–1. If let out on the ebb it would flow up again 12 miles above the outfall, 7848. Four hours after high water is stated to be the time when they stop the outflow, but his observations tend to show that it must be three hours, because on many occasions the water does not fall sufficiently low to enable them to empty the reservoir until that time has elapsed, 7849–50. Has no doubt from the construction of the reservoirs and the level of the sewers, they were originally made with the object of treating the sewage chemically, or in some other way, 7851–6. The bottom of the reservoir is many feet below the level of the lower lip of the sewer, and the sides of the reservoir cannot be built up because the reservoir being so low the sewage cannot be discharged fully until three hours after high water, instead as was intended on the whole of the ebb tide. If a quantity of sewage were left in the reservoir it would putrify and make the sewage more offensive than it is at present. The floor could be raised if the reservoir was on a higher level, but it would require an enlargement of the discharging capacity to obviate the possibility of the penning back of the water in the sewers, 7857–62. The gorging of the sewers would be objectionable, but so long as a sufficient fall is maintained to keep the sewer clear, it could be got over. Merely increasing the area would not diminish the defects arising from the depth of the level, 7863–5. Trinity high water is 12 ft. 5 in. above Ordnance datum. Low water is 7 ft. 6 in. below datum. The mean half tide, therefore, is 2 ft. 5½ in. above datum. He makes the mean nearly 2 ft., which agrees with diagram No. 9, in the Engineers' Reports of 6th April 1858. Mean high water is shown on the diagram at 11 ft. above datum, and mean low water at 7 ft. below datum, while mean half tide is given as 1·5 ft. He makes the mean half tide to be 2 ft. and not 1·5 as stated by Sir J. Bazalgette. The practical result is that the reservoir never can empty until half-tide level, 7866–74. Has never seen the suggestion in any of the Metropolitan Board of Works' Reports, that Thames water is used for flushing the sewers; many of the sewers are at such a level that it is utterly impossible to get water into them from the Thames for the purpose of flushing them, 8354–6, 8478–82.

## Mr. JAMES MANSERGH, Mem. Inst. C.E., F.G.S., F.M.S.

Has been in practice as a civil engineer for nearly 30 years, almost exclusively designing and carrying out works for the disposal of sewage and for water, and has advised and reported on about 200 schemes for water supply works and sewage works, 8502–5. He received a premium for his scheme for the Lower Thames Valley drainage, and has carried out drainage works in about 60 different towns, 8506–13. Was a witness for the Thames Conservancy in the Mud Inquiry, and made himself thoroughly acquainted with the river and the discharge of sewage into it, 8514–16. He was associated with Mr. Baldwin Latham in preparing evidence for this Commission, 8517–18.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—In very dry and hot weather the discharge of sewage into the river must cause a very great nuisance, and "between bridges" it is evident that a gradually increasing nuisance is threatened, because of the increase of the population having already overtaken the calculations that were made in 1858 when the scheme was laid down. The effect is that the storm overflows must come into action more frequently than was then contemplated,

## Mr. JAMES MANSERGH—*continued.*

Scientific Evidence as to the foul State of the Water in the River near the Main Outfalls—*continued.*

and the sewage gets into the river at London instead of at Crossness. He believes also that at Grosvenor Road Pumping Station the pumps pump direct into the river very frequently, 8586–93, 8639–40. In the reports of Sir J. Bazalgette in 1856, it was stated that deodorization would not be necessary if the outfalls were made as low down as Barking, 8623–4. In 1858 the gentlemen associated with Sir J. Bazalgette, viz., Messrs. Bidder and Hawksley, reported (*see page* 145) that the sewage due to the (then) population of the metropolis amounted, including some rainfall, to about 80,000,000 gallons a day, and estimated the cost of deodorizing it at 20,000*l.* per annum. From these reports he concludes it was their intention to deodorize the sewage in warm weather, and in cold weather it was to be so treated that the suspended matter would be precipitated and retained, and not sent into the river, 8625–35. In his opinion this idea should have been acted on, as the discharge of sewage in its crude untreated state into the river creates a nuisance which ought to be avoided, the more so as some of the organic matter is deposited in the river which in hot weather comes up to the surface and causes an abominable nuisance, 8636–8. At the northern outfall, when the sluices are opened at the top of the tide, and when for half an hour there is practically no current, the whole river is covered with sewage, and for a short time it causes a great nuisance to the locality, 8648. The discharge from the sewers, as shown in Table M. 3, includes all the fouled water supply which is what is technically known as sewage. The actual excreta is not the only polluting matter in the river, but kitchen water and all kinds of other things which increase the polluting element, 8925–32.

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—At certain times of the tide, near the top and bottom of the tide, the velocity of the current is much less than it is in the intermediate part of it. The curve of the water at the top of the tide for an hour or two is a very flat one, and it becomes sharper as the tide begins to run down, and then it is flatter at the bottom. As the tide slackens there are, as it were, times of rest which give great opportunities for the solids to be deposited on the bed of the river. So, both at high and low water at Barking, or any other point in the river above or below, the river is to some extent a settling tank, 8641–7. A great proportion of the solids sinks to the bottom. Some of the organic matter is deposited and mixes with the argillaceous matters held in suspension in the river. It goes down with them to form the banks, and then in very hot weather that matter rises and forms patches of stinking matter which gives rise to the greatest nuisance that ever occurs, 8727–9. During the Mud Inquiry he plotted a number of cross sections to satisfy himself whether by the dredging operations on the north side the sectional area had been abnormally increased and consequently the velocity diminished. He found this to be correct, and that there was a swelling or aneurism in the river. He plotted these areas *after* the mud had been removed, but as if *the mud had not been deposited.* Then he plotted similar areas *in* the river and found that instead of an aneurism there was a constriction; the river, instead of being too large, was too small. He hands in a drawing which explains this (see Appendix X), 8730–4. The plotting of 1882 shows a slight increase over that of 1878, which proves that the cause of these accumulations is going on at present, 8735–43. These sections were plotted from the Thames Conservancy Surveys, and he took the distance of six miles each way from the middle of the Halfway Reach, as being a fair length, and not with any regard to the possible results. Had he taken five miles only, there would have been an aneurism against him and a constriction in his favour, 8744–53, 8816. The sewage discharge keeps the bank in this place. There is a constriction at Margaretness and at Barking, but Mr. More can give information on these points better than he can. The sectional area in Erith Reach is just about the normal, according to this test, 8754–67. Hands in sections of the river above and below the outfalls. The result of his survey shows that what was an aneurism has now been turned into a constriction by reason of the deposit of mud (see Appendix X) (§ preceding Q. 8815), 8949–55. The reason the section of the river showing the aneurism was not put in as evidence at the Mud Inquiry was because it was not considered expedient by the Counsel to bring it

Mr. JAMES MANSERGH—*continued.*

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

forward, 8734, 8822–4. He agrees with the paragraph on page 26 of the Report of the Arbitrators in the Mud Inquiry as to dredging operations having caused the banks, and altered the direction of the flow of the currents and tide, so as to produce a diminished velocity, but there is now no increase in the sectional area, but a diminution, 8900–3. He does not object to the finding of the arbitrators, but says, as they say, that a part of the banks is formed from the discharge of the sewers in consequence of the diminution in the velocity, which causes the solid matter in suspension to deposit and help to form the mud banks. Of this of course only a part is due to sewage, but it is that part which creates the nuisance in hot weather, 8914–24. Comparing his section with the state of things before the Mud Inquiry, there is undoubtedly a constriction in the river, and the increased velocity ought to scour away the banks, which it does not do, or if it does it re-deposits almost immediately, 8949–55. He now hands in a table giving the areas of the river in Halfway Reach in 1882 as compared with 1861, with regard to the alleged constriction. They extend over 1½ of a mile of the river, between 5 W. and 2 E. Cross section 5 W. is in the middle of the bank about 900 yards above the southern outfall, and 2 E. is about 1,100 yards below the southern outfall. Of these cross sections, the areas of 2 W. and 1 W. are a little larger now than they were in 1861. The rest are a little smaller. The section where there is a considerable reduction is lower down than these to which he now refers, 9065–8. His sections of 1861 are founded on the bases of the Conservators' surveys for that year, and they refer to the sections of the river before the Dagenham shoals were removed, and of course before the mud was deposited; and although the river was made too big by the dredging at Crossness Banks, it has has grown up since. During a wet year, as in 1882, the increase of the flood water would tend to increase the sectional areas, and causes them to vary at different times of the year, 9068–75.

Distribution of the Sewage in the River by the various Motions of the Water.—In conjunction with Mr. More, he has prepared a longitudinal section of the Thames from Teddington to Southend, which he hands in (*see* Appendices W. 1 to 4), 8519. To obtain this section, 133 cross-sections were made, and the cubic capacity of the river has been obtained by this means, 8520–1. Hands in a table which gives the capacity of the River Thames as shown on longitudinal sections marked respectively A′, A, B, B′, 8522–4, 8539–63. He has marked this Table of capacity M. 1., 8573. The two first were taken at spring tides, viz., on the 1st and 30th of October 1882. On the latter occasion the river was in flood. The other two were neap tides, 8525–31. There are two colours on the chart or section, light blue and dark blue. The line dividing the two colours shows the surface of the water from Southend to Teddington, at the moment of low-water at Southend, and the upper line shows the surface of the water from Teddington to Southend at the time of the following high-water at Southend. These lines may be called synchronous lines. The dark blue colour shows the quantity of water which entered the river from above Teddington, and from the tributaries between Teddington and Southend, as well as from the sea, between low and high-water. The light blue colour represents the water in the river at Southend at low-water, 8532–38. There was a difference in the quantity of water at high-water in the river on the 6th October of one-twelfth more than on the 4th November 1882, although on the latter day there was 5½ times as much land water coming in. This was due to the fact that the wind on the 6th October blew from the east, which tended to keep both the high and low-water up; whereas on the 4th November it blew from the south or west, which would have a contrary effect, 8564–70. The water impelled into the river from the sea upon a high spring tide is, roughly speaking, twice as much as on a low neap tide. It tends to raise low-water from Teddington to London Bridge, but it does not affect anything much below that point. It is the tidal wave which fixes the height of the tide, though modified by the wind, 8571–73. The heights upon Roberts's tide tables are the calculated heights, 8576–7. Hands in a longitudinal section of the river Thames, showing the sectional areas between Teddington and Southend. On the section a line is put which shows the mean line between absolute high-water and low-water heights. It has been deduced from

Mr. JAMES MANSERGH—*continued.*

Distribution of the Sewage in the River by the various Motions of the Water—*continued.*

a number of observations of the self-recording gauges at various places on the river, 8574–85. This table is marked M. 2., 8581. The progress of the sewage to the sea has been worked out from the two factors, viz., the displacement by upland water, and the displacement by mixing with the sea water, and not from the float experiments. Unless taken in conjunction with the chlorine tests, they would practically give no information as to the progress, 8649–51. The influx of the tide diminishes the area available for the passage of the land water, and therefore increases its velocity. If the upland water flowed into a lake or tideless sea, and the channel of the river had the same slope and sectional area throughout, the daily progress down the river would be the same; but the progress would be diminished if the sectional area was increased in an inverse ratio to the increase of that area, and vice versâ, 8652–63, 8676–81. The mixing action takes place whenever fresh and salt water come together, and it is facilitated by eddies, currents, winds, and the screws of steamers, 8664–7. He shows a diagram explanatory of the way in which molecules of fresh water are surrounded by sea water as they move up and down the river, and are therefore forced down to the river by their increased size, as they cannot occupy the same position they did when fresh water only, 8668–72. Whoever invented the chlorine tests, in his opinion, has done great service, and he has adopted them. They give a mode of measuring the mode of progression which was never thought of before, 8673–5. He has prepared some other tables marked M. 3a, M. 3b, M. 3c, and M. 3d, which he hands in, 8682. The object in preparing these tables was to make out the time in which the land water with the sewage in it would progress to the sea, and he has worked upon somewhat different lines to Mr. Baldwin Latham for the purpose of explaining it in a clear way, and of checking their relative results, 8683. The two days, viz., 14th of September and 30th November, werechosen, as on the first day there was a comparatively small quantity of land water, and on the second day there was a comparatively large quantity coming down, 8684–5. Taking Crossness as the middle point, because there are 30 miles above and 30 miles below, he has divided the river into 12 parts of five miles each, six on each side of Crossness. The tables give the divisions of the river, the chlorine found by analysis, the contents of the river, the percentage of sea water (from chlorine), the quantity of sea water, the percentage of upland water, including sewage (from chlorine), the quantity of upland water and sewage, the quantity of upland water at each division (by gaugings), &c., &c., in each division, and the time taken to progress through each division, and the total time from Teddington to Crossness, and Crossness to Southend. The measured quantity of water of upland water entering the river in each division is calculated as coming in at the upper end of that division; the sewage discharged at Barking is calculated at 14,760,000 cubic feet, and at Crossness 11,240,000 cubic feet in 24 hours. Upland water is taken as containing 1·7 parts of chlorine, sewage 10 parts of chlorine, and sea water 1,961 parts of chlorine per 100,000 parts. It has been assumed for the purpose of calculation, *but not admitted*, that there is no sewage in the river above Barking, 8684–8715. The results obtained from these tables agree almost exactly with Mr. Baldwin Latham's calculations, 8717. A big flood cleans the river and accelerates the progress to the sea, so in very hot weather, when there is little water coming down, the rate of progress is retarded, 8718. There is no doubt that there is sewage above Barking and Crossness, but he is unable to satisfy himself sufficiently as to the *measurement*. He is dealing only with the volume of sewage discharged from the outfalls, and leaves it for chemists to say whether it maintains its polluting and nuisance-creating character all the way down the river, 8725–6. In his tables he has derived the percentage of sea water (from chlorine) and the percentage of upland water, including sewage in the way that Mr. Baldwin Latham explained, and he has used the same formula $\frac{A - B}{A - C}$. A = sea water, B = river water, and C = the chlorine in the sample found, which is 4·7 in the fifth division above Crossness. The accuracy of the tables depends on the assumption that the quantity of chlorine in the sewage, fresh, and sea water are correct; but below Crossness, if they are not correct, it would have very little effect

## Mr. JAMES MANSERGH—*continued.*

### Distribution of the Sewage in the River by the various Motions of the Water—*continued.*

indeed, 8768–88, 8936–39. If the sewage contained 20 parts of chlorine instead of 10 parts, it would make a correction and reduce the sectional areas due to sewage and water; but it would be of very little importance down to Crossness, and below Crossness would make very little difference in diminishing the rate of progress, 8789–91. The tables give the rate of progress to the sea, but the means of the tables must be taken, not each table separately, 8792–8802. At any given ebb tide half the content of the water between Barking and Southend goes down the river towards the sea, but does not actually *go out to sea*, because a proportion of it flows back with the following tide, though mixed with water which has been moving backwards and forwards for some time probably, 8803–14, 8854–70, 8942–44. He hands in diagrams on which sections of the river are plotted, showing the line of high-water up and down the river on the days mentioned in his Tables of Capacity. The synchronous lines of high-water, low-water, mean flood, and mean ebb, at Southend and Barking, are represented. (*See* Appendix Y.) The blue line, which represents the normal river, is a straight line, as the curve of the sectional area proportionate to the water above it is so flat as to be impossible to show it as a curve, 8815–21. The basis of the tables M. 3, &c., is founded on the assumption that the upland water and sewage are in the proportion that the quantity of water gauged as coming over Teddington Weir and other tributaries bears to the quantity of sewage discharged from the outfalls on any given day, and also assuming that sea water contains 1,961 parts of chlorine, 8825–42. If on the 30th November 1882 the sea water at Southend contained only 1,785 parts of chlorine, it would be due to the quantity of land water which had come down during the past few days, and diluted the sea water. Produces a paper showing on what his analysis was based, which is the same as Professor Way's, 8843–46. The upland water would affect the salt water at Margate, but not over the whole of the estuary. Very possibly 12 per cent. of the sea at Margate is fresh water, 8847–53. In calculating the rate of progress to the sea, Southend was fixed on as being the end of the river in order to avoid any complication with the Medway. Although the Medway water is brought up by the tide, it makes very little difference in the chlorine tests as regards the lower portion of the river, and at Barking and Crossness the Medway water would not affect the question, as the tidal oscillation would not bring the water up so far in one tide. Any excess of chlorine at Westminster would be accounted for by the presence of water from below Southend, 8871–85. The tables do not take any account of the extent to which the sewage has been destroyed by decomposition. They merely represent the quantity which comes down through the sewers. Sewage put into running water is destroyed to some extent, but how far he prefers to leave to the decision of chemists. Running water purifies sewage to some extent, but he believes a good deal of the solid matter in suspension is deposited in the bed of the river, 8891–99. He is perfectly satisfied that the figures in his M. 2 table are accurate, and that no mistake took place in taking the figures for one section from the wrong gauge. He has no objection to produce his cross-sections, which are 134 in number, 8904–13. As regards the results of the oscillation of the sewage, the lower reaches of the river are not so important as the 15 miles below Crossness, 8933–35. He has re-checked his formula for working out the percentage of chlorine in sewage, and the supposed error was due to the fact that he had not worked out the percentages beyond one place of decimals. The accuracy of his figures is proved by carrying the figures further. Thus,

$$\frac{1{,}961 - 4{\cdot}7}{1{,}961 - 1{\cdot}7} = \frac{1{,}956{\cdot}3}{1{,}959{\cdot}3} = {\cdot}9984688 =$$ the proportion of upland water. Multiplying this by 1·7, which is the amount of chlorine in upland water, it gives 1·6973969. Deduct upland water from 1 the remainder is ·0015312, which, multiplied by 1,961 (the chlorine in sea water), gives 3·0026832, and that added to 1·6973969 makes a total of 4·7000801, which is the exact figure in the first column of the table, 8936–9. There is a difference between the sea water at Margate as compared with the sea water at Southend. At high-water there is a little more chlorine at Southend, and at low-water there is considerably less than at Margate, 8940–1. The float experiments cannot be relied on for actual calculation, but only show the range of a certain part of the water, floating up and down and, given that range of the tide, no great volume of the Medway water can get very far up the river as fresh water. Above Southend it must be very largely diluted, 8945–8.

## MR. CHARLES JAMES MORE, Mem. Inst. C.E.

Engineer to the Conservators of the River Thames.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—In the summer time there is a most offensive smell in the reaches from the river, which he has noticed even at Woolwich. It is especially bad between Woolwich and Erith. It is horrible when the mud is stirred up by a steamboat. In the winter there is no smell, 9010–12, 9049–50. He has frequently seen the sewage running out from the northern outfall in a small stream until low water, and it would of course be carried up on the flood, 9013–15.

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—He has been constantly on the river between London and Gravesend during the last 13 years, and has personally surveyed the river from London Bridge down to the lower end of Long Reach, 8961–6. Accumulations of mud are found in various places, extending in some parts right across the bed of the river, and in others only in bights. He hands in three plans, showing exactly the present condition of the bed of the river and the deposits of mud, gravel, clay, and peat (*see* Appendices Z 1, 2, and 3.), 8967–8. The mud varies in depth from six or seven inches to eight or ten feet, and it is evident it has been brought there, as the bed of the river was originally gravel, 8969–70. In Bugsby's Reach there is very little mud, except on the foreshore, on both sides until you get to the lower end of it. The amount varies according to the season and the rainfall. Woolwich Reach is very muddy indeed, and it extends almost across the river. The depth of mud here varies year by year from one to two feet. Galleons Reach is very muddy all along the Bight on the Essex shore. Near the Beckton gasworks there is a great depth of mud, and it extends as far as Barking Creek, round the lower end of the bight. It is six or eight feet deep, 8971–9. From Margaretness on the north to Crossness on the south, and from False Point to opposite Dagenham, is very muddy nearly across the river, and varies slightly only. Halfway Reach is very muddy, especially on the south side where the southern outfalls are. It is nine or ten feet deep far out into the river, and is extending further down the reach. There is mud also off the north side opposite Jenningtree Point. From here all the way down to Erith on the Kentish side is muddy, and it increases in the lower end of the reach. Off Erith it is six or seven feet deep and extends about one third of the way across the river. It has increased lately. There is not much mud round Erith Rands until you reach Crayfordness, when there is mud down the centre of Long Reach, 8980–96. Between high and low water mark there is a great deal of mud all the way down past Gravesend, 8997. He remembers places which were quite clean, and you could land from a boat without difficulty, which are now covered with three to four feet of mud. The locality of the deposits does not change much, but the depth varies slightly, and the area increases year by year, especially in the neighbourhood of the outfalls, 8998–9001. The mud is very black and shiny, and of a more offensive character near the outfalls than elsewhere in the reaches. It is very much complained of by the men employed by the Conservators to raise anchors and wrecks It is blacker than mud found further away. Down as far as Sea Reach this offensive mud is found, 9002–6. The survey of 1861 does not contain the soundings of the mud, so it cannot be compared with his chart which he has handed in, but he can from his own observation speak to the offensive character of this mud, 9007–10. He has prepared a plan of the bed of the river for the years 1877, 1878, 1879, and 1882. The latter is of Barking and Halfway Reach. Has also prepared sections of the river, which he hands in. (*See* Appendix A.A.) They go right across the river, and are for the years 1832, 1861, and 1882, 9017–23. They show a good deal of dredging between the years 1832 and 1861 in Erith Reach and at the Rands, and between 1832 and 1882 they show a very large

## Mr. CHARLES JAMES MORE—*continued.*

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

accumulation of mud on the south side, which has taken place principally between 1861 and 1882, 9024–8. Contemporaneously with the growth of the mud banks at Barking, Margaretness, and Halfway Reach, dredging operations have been going on, as was the case at the time of the Mud Inquiry. The result of the artificial deepening of the river on one side has been to cause the mud to silt up on the other side, and so increase the sectional area. Dredging was carried on to a certain extent near Erith between 1861 and 1882, 9037–48, 9051–4. No dredging has been done opposite the southern outfall since the date of the Mud Inquiry, and the accumulation is still going on. Dredging generally has the effect of increasing the sectional area. In recent years dredging has taken place principally in Erith Reach, 9055–7. Is unable to say without further examination of the sections whether the sectional area of the river in Erith, Barking, and Halfway Reaches has largely increased, as compared with 1861, but it may be accepted that the accumulation of mud has, apart from the dredging, diminished the area. 9058–64. The cross-sections were taken about September last year. (This refers to the sections which Mr. Mansergh put in, but could not give the date when they were taken in 1882), 9076–9. He now hands in two tables, one giving the area of cross sections of the Thames at Erith, and the other showing the increase or decrease in the areas at Erith between 1832, 1861, and 1882 (*see* Q. 9062.), 9079*a*–83. The figures quoted by Captain Calver at the Mud Inquiry on the increased sectional area of the river from Barking to Erith, between 1861 and 1879, were not compiled by witness. The materials were supplied from the Thames Conservancy office to Captain Calver, but the calculations were made outside the office, 9084–98, 9101–3. Between 1879 and 1881 a number of shoals were removed from the river near the outfalls by dredging, but not at Dagenham after 1879. There were extensive dredgings though in Erith Reach, 9099–9100. There is an increase in the sectional area opposite Erith town causeway between 1861 and 1882, but all the others show a decrease. There has been dredging in that reach, no doubt, which would account for the increase, 9104–9.

Set of the Tide.—He took no part in the float experiments recently, but he has taken float observations some time ago. They were taken for the purpose of observing the set of the currents, and not to ascertain the distance an object would float with the tide, 9029–31. In the crooked parts of the river above Long Reach the flow of the stream is very variable, much more so than in the lower reaches. There are eddies of different velocity round the points and upon different sides of the reaches, and at different points of the reaches, which would fully account for two floats in the same reach making different journeys. If one got into an eddy, it would remain there a considerable time. Objects in the reaches would be more subject to the influence arising from the shape of the reaches than objects outside the reaches, 9032–6.

## Mr. R. W. PEREGRINE BIRCH.

Member of the Institution of Civil Engineers.

Scientific Evidence as to the foul State of the Water in the River near the Main Outfalls.—While making the float experiments, the river was not at all favourable to the development of any nuisance from the sewage, as from the middle of September to the early part of November the weather was cold, 9286. The surface of the river must be very striking to anybody constantly passing up and down the river. He has drifted up on a steamer and seen the most undisguised sewage on the surface, as high up as Blackwall and down to Purfleet, nearly every day, floating either in the currents or lying on the sides, marking the distinction between the slack places and the stream. Standing on the sponsons of the tug, he has received the spray in his face, which reminded him of the sewage most distinctly. This he has noticed as far down as Erith, 9287–9. The temperature of the water was considerably lower than the summer temperature, 9289–90.

Discharge from the Storm Overflow Outlets.—On the 22nd October 1882, when in Deptford Creek after a considerable fall of rain, there was an extensive overflow from the storm outlets, and he saw more solid

## Mr. R. W. PEREGRINE BIRCH—*continued.*

Discharge from the Storm Overflow Outlets—*continued.*

sewage floating on the surface of the water than he ever saw floating on the surface of any water in his life. By solid sewage he means human excreta. It must be a serious disadvantage to people having property in the Creek. It was about half ebb tide, and the sewage was floating out of the creek with the stream. It certainly did not come from the main outfalls, 9292–9310.

Distribution of the Sewage in the River by the various Motions of the Water.—He served his time with Mr. Abernethy, and so gained a considerable experience in tidal matters. He has also devoted considerable attention to questions connected with the disposal of sewage, 9110–13. He was engaged by the Port Sanitary Authority to make a series of tidal experiments in 1882, and on the 17th September he commenced operations between Barking and Southend on the north, and Northfleet and the Isle of Grain on the south side of the river. He also made arrangements for the daily gauging of all the streams between those points. To effectually superintend the operations he took up his quarters on the steam tug "Toby," and he and his assistants were at work for 18 to 20 hours a day during the whole time, 9114–24, 9356–61. Six floats were put into the river at different stations, and were watched day and night, and he believes the experiments were fairly conducted, and has no reason to believe that the floats were tampered with, 9125–36. The floats were left to take their own course, except when there was danger of their running aground, when the men had orders to pull them out into the stream, and the results are no criterion of the progress of sewage to the sea. They were merely tidal experiments, 9137–40. The floats upon a flood tide are less affected by lateral influences, such as wind and irregularity of course, than the floats upon a neap tide. It is due to the greater velocity of the flood tide over the ebb. The land water comes down with the ebb in greater quantities than that which goes up with the flood, but the time it takes to come down is increased in a much larger degree than the volume is increased, 9141. He has made a calculation, which he hands in, showing that the velocity of the flood tide at Barking is greater than that of the ebb tide by 20 per cent., 9141–3. This would account for the longer distance traversed by the floats on the flood than on the ebb, and for their keeping a better course. It tends to show also that the flood would have the effect of carrying up any deposit from the mouth of the outfall, and depositing it higher up, 9144–8. The agent which principally effects the scouring of the river is the fresh water from the river, and the new water from the sea, not that water which is oscillating backwards and forwards, 9149–51. The quantity of sewage leaving the river depends upon the quantity of fresh water coming in, which is dependent on the up-country rains, and the character of tides at the time, 9152–3. He has worked out in diagrams the particulars of the three days, the 14th and 22nd September, and the 30th November 1882, which Mr. Latham and Mr. Mansergh worked out in tables. These diagrams he hands in. (*See* Appendices A. B., 1, 2, and 3.) Although he has worked it out in a different way, the results are practically the same, 9154–6, 9222–9, 9337–47. On the 14th September there was a spring tide and the flow at Teddington Weir was 8,332 cubic feet per minute. On the 22nd of September there was a neap tide, and the flow at Teddington Weir was 122,451 cubic feet per minute. On the 30th November the tide was between spring and neap, and the flow was 476,345 cubic feet. There was a very great flood on that day, 9157–61. The first diagram shows the respective quantities of sea water, inland water, and sewage in the various reaches of the Thames on the 14th September from Barking to Southend, and it also shows that the northern sewage of the 16th August, mixed with the Teddington water of the 4th August, reaches Southend on the 14th of September, taking 30 days to travel from Barking to Southend. Every day's upland water and sewage which affects this diagram is localized longitudinally by the red lines across the white column, and its volume shown on each block in red figures. Each of these blocks is supposed to contain 26,000,000 cubic feet of sewage. The day upon which each block of water came over Teddington Weir is also shown. The same details are shown on the other diagrams, 9162–8, 9183–9206, 9235–7, 9315–25. At Southend the white column is smaller because there is less fresh water than there is higher up, but it travels faster. He adds that the diagram is not a true plan, but a

## W. PEREGRINE BIRCH—*continued.*

### Distribution of the Sewage in the River by the various Motions of the Water—*continued.*

developed plan. It represents what width the river would be if it were one foot deep all over, 9169–72, 9221. He attributes the greater rapidity of the column of water at Southend to the influx of sea water, which reduces the cross sectional area. If the area is increased, the velocity is reduced, and vice versâ. But for the action of the sea water, the velocity at Southend would be be a twelfth of the velocity at Barking. As it is, it is a little faster than at Barking, 9173–7, 9214–20, 9231–4. All this is founded on the salt test, and it is absurd to say that 1961 parts of chlorine is the wrong standard, as at Margate 1950 grains have been found in the salt, and he has no doubt thet the normal quantity in the middle of the estuary would be 1960 grains in 100,000. To put it as low as 1700, would be absurd, 9178–81, 9258. He omitted to explain that in the diagram the line upon the upper side of the dotted line shows the limit of the high water capacity, the lowest hard blue line shows the low water capacity, and the two outer dotted lines and the two inner dotted lines show respectively the limits of the mean river capacity and the mean fresh water column. As the limits of the mean fresh water column are wonderfully near the limits of the high water column on the one side, and the limits of the low water column on the other, he considers he is quite justified in taking the mean as the average column of the day, 9182. To ascertain the progress to the sea, the velocity is obtained from the cross sectional area of the column. Then dividing the day's supply in cubic feet by the sectional area in square feet, the day's progress to the sea is ascertained with accuracy, that is, if you could see the column, which is impossible. Salt tests are therefore resorted to, and by ascertaining the amount of chlorine you learn the amount of salt there is in the water, 9207–13. Taking the second diagram for the 22nd September, there were 32 days' flow of inland water and sewage between Barking and Southend, and on the 30th November, when the river was in flood, there were only 11¾ days' flow of inland water and sewage between these two points, 9235–47. On the 14th September the sewage would be diluted by eight times its bulk, on the 22nd September by 14 times its bulk, and on the 30th November by 30 times it bulk of water, 9248. Similar details are given as regards Greenhithe, Gravesend, and Southend, 9251–7. This is shown on the diagrams, and also on the tables put in by Mr. Latham and Mr. Mansergh, 9249–50. If the quantity of chlorine in the sewage was taken to be 20 parts instead of 10 parts in 100,000 parts, it would make no difference whatever in his calculations, as it would increase the quantity of chlorine in the upland water by $\frac{1}{1959}$th part only, and would make only 20 minutes difference in a month in the period taken by the sewage to travel from Barking to Southend, 9258–62, 9326, 9333–34. The water from the Medway cannot enter the Thames to any appreciable extent because the Medway water has to escape to the sea in exactly the same way the Thames water gets out. Now at Barking the water which did not come from the Thames is equal to one-fiftieth part of the sea water at Southend, and as the Thames is 10 times the size of the Medway, it follows that only one five-hundredth part of the water at Barking could be Medway water under the most favourable circumstances, and he does not profess that his calculations are nearer to accuracy than one five-hundredth part, therefore he is quite satisfied if there is no greater error, and the mixture of Medway water would not therefore be appreciable at Barking. It is the greater specific gravity of sea water which causes it to penetrate the fresh water, and it is forced up by the rise of the tidal column. If the sea water and fresh water were of exactly the same specific gravity, the effect of the tidal column coming in would be simply to raise the fresh water as against the salt, 9263–80. The diagram he handed in, showing how the fresh water is got rid of at the mouth of the Thames, applies equally to the Medway, and the difference of specific gravity acts quite as strongly on the Medway water as it does upon that of the Thames, 9281–3. He has not built any argument upon the salt survey with regard to the sewage pollution above Barking, but has applied this process simply to the river between Barking and Southend; but there can be no doubt that the sewage discharged on the last of the ebb must go up with the flood nearly the whole range of the tide, which is 11 or 12 miles, 9284–5. His diagram is based upon the supposition that all sewage passes from Barking downwards to the sea, and any water that has



## Mr. R. W. PEREGRINE BIRCH—*continued.*

### Distribution of the Sewage in the River by the various Motions of the Water—*continued.*

gone through the London sewers he calls sewage. The diagram does not depend at all upon any solid matter at the bottom of the river, but only deals with the column of water coming from the sewers. The only thing that bears upon the deposit at all is that the flood tide is stronger than the ebb, 9300–5. Chloride of sodium, being a soluble matter, would, if it existed in any suspended matter, be dissolved out and washed down by the tide, 9313–14. Chloride of sodium is, he knows, taken as a test of the pollution of pure water by sewage, but not in sea water. Not being a chemist, he does not understand chemical analysis, and his calculations do not therefore refer to pollution, but to the mixing action only, 9327–36. In comparing Mr. Mansergh's tables with his diagram for the 14th September, the discrepancy between the two sectional areas at Crossness may be due to the fact that the same points have not been taken by each, and also there may be an error in taking the dimensions of the column of water at the Barking end synchronously at the different points, 9348–55. Any complaints which may be brought against the men who had charge of the floats he will inquire into on receiving the particulars of the charges, 9362–7. Samples of water for the purpose of ascertaining the amount of chlorine in the river were taken, he believes, at St. Paul's Pier, Deptford, Barking, Crossness, Erith, Gravesend, and Southend, at high and low water on the 14th and 22nd September, and on the 30th November, 9368–73. The discrepancy referred to at Questions 9348–55 he now explains. It is due to the intermediate divisions being interpolated by the eye, and not accurately interpolated. If you get half a day out upon each side, it makes a difference of an addition or a deduction equal to a day's flow, 9779-81*a*. His distances cover an area of 29½ miles, while Mr. Mansergh's area is composed of six divisions of five miles each, and this causes an error in the totals of about five or six per cent. When he found that it was in favour of the Metropolitan Board of Works, he did not go further into the question, as he would have done had it been against them. It gives in fact a quicker progress to the sea of one day and a half, 9782–90. He has made inquiry of the men in charge of the floats, and supplies the names which were applied for (*see* Questions 9362–7). The complaints brought against these men were handed to him since the last meeting of the Commission, and he has received denials from the men that they had done wrong in any way. During the time the experiments were going on, he received no information of any misfeasance on the part of the men, and he had no reason to be dissatisfied with them, 9790–9804.

## PROFESSOR WILLIAM CAWTHORNE UNWIN.

Member of the Institution of Civil Engineers, and Professor of Hydraulic and Mechanical Engineering at the Royal Indian Engineering College, Cooper's Hill.

Distribution of the Sewage in the River by the Various Motions of the Water.—There are only two ways in which the volume of sewage discharged into the river can disappear from the river and so escape, being considered a question of hydraulics. Part may escape by decomposition into gas, but that volume would be very small; and part may be deposited upon the bed of the river, and would no longer form part of the flow of the river; but there are no means of ascertaining what proportion of sewage disappears in that way. He supposes it is then still in the river, and still liable to do injury to it, 9373–7. The portion that remains in the river he deals with for the purpose of representing the sewage, and what goes into the river he considers, for his examination, as remaining in the river, 9378, 9380, 9722–9, 9769–70. The extent to which the sewage in the river is noxious or innocuous he leaves entirely to chemists and biologists, 9379. In ascertaining the principles which control the movement in a non-tidal river, the quantity of water between two sections must be constant, so that the quantity of water flowing in at one end is equal to the quantity flowing out at the other. But if the river carries different materials, such as river water, sea water, and sewage, then the quantities of each flowing in must be equal to the quantities of each flowing out, 9380–4. In a tidal river the volume between any two sections is constantly changing with the height of the tide; but if the alteration from day to day of the range of the tide be neglected, then at

PROFESSOR W. C. UNWIN—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

corresponding phases of the tide the volume between two sections is the same, 9385–7. The down stream displacement at every section in the river must therefore be, in each tide, the volume of the upland water divided by the area of the section, and the displacement due to the upland water alone will vary with the area of the section, 9388–91. Local currents and other differential motions of different portions of the river cause some slight modification of the displacement, which produces the mixing action of the sea water with the river water. So also the sewage may sometimes be carried by the range of the tide higher up or lower down than it would ordinarily be taken, displacing an equal quantity of upland water, and this must be repeated upon every tide, 9388–9402. The same remarks would apply equally in a straight reach, like the Dee at Chester, because in the straightest reach the central or surface portions move about 15 per cent. faster than the mean, and about 25 per cent. faster than the bottom. It is a principle applicable to all streams, though it is rather difficult to say whether the local causes would apply to a winding river like the Thames in an equal or greater degree than to a straight reach. Probably there would be more local currents in a winding stream, 9403–8. According to this theory the foul water from Crossness might work up to Teddington or to a point not more distant from Teddington than the upland water displacement in the period of a tide. Close up to Teddington it would be driven back by the upland water, 9409–10. In the part of the river below Crossness the effect of the mixing action is to make the Crossness water go down stream quicker than it otherwise would, and that water which goes down is balanced by the sea-water which comes up to Crossness. So also when any foul water (that is, the Crossness water) gets higher up than the mean, a similar quantity of pure water goes lower down than the mean to fill its place. In a river consisting of different materials this displacement has the effect of distributing all those materials over the whole length of the river; but in a river consisting entirely of fresh water it would have no practical effect, 9411–15. During the flow of a spring tide about 24,400,000,000 cubic feet of sea-water flow into the river at Southend and mix with the foul water up stream, carrying part of it back to the sea. If, however, the Thames was an arm of the sea, having no supply of upland water, then, apart from the mixing action, it would gradually fill up with sewage; but in consequence of the mixing action a portion of the sewage would still travel out to the sea at a considerable pace at each tide; but he is unable to say in what proportion to its present pace, 9416–21. On account of these influences, where sea-water has passed to a higher point than where it started from, the mixture must go to the tidal limit, except the distance occupied by the quantity of upland water that comes in during one ebb. Supposing there was no upland water, it must still go to the top, and even in a narrow estuary (so to speak) the effect would be the same. He does not speak of the quantity; the curve may be asymptotic, or it may become excessively small, 9422–5. The extent to which sewage would come up the river is a matter of degree according to his theory, and would depend partly on the position of the outfalls, and matters of that kind. As it is, part of the sewage discharged from the outfalls flows back through the whole range of the metropolitan district, which was contrary to the intention of Parliament when passing the Act, 9426–32. He has prepared some diagrams and tables from data supplied to him of three tides during which observations were taken. The days were September 14th and 22nd, and November 30th, 1882. From Professor Way he received chlorine analyses of the water at Teddington, Chiswick, St. Paul's Pier, Deptford, North Woolwich, Barking, Crossness, Erith, Gravesend, and Southend, at high and low water. From Mr. Mansergh he received computed sections of the river at high and low water at these ten places; and from Mr. Baldwin Latham he received gaugings of the water coming over Teddington Weir, and the water coming into the river from the tributary streams. These diagrams and 13 tables he hands in (*see* Appendix A.E., 1 to 21), 9433–42, 9627–33. Diagram No. 1 represents the horizontal oscillation of the tide for two tides, a spring tide and a neap tide, and he ascertained this by computing the volumes of water in the river above each of the sections at high and low water. For example, in Table 2, on the 14th September there were 10,474 cubic feet above St. Paul's Pier at high water, and 10,210 cubic feet at North Woolwich at low water, and he says that the horizontal oscillation of the tide at those places was from North Woolwich to St. Paul's Pier, because the water which occupied the space above St. Paul's Pier at high tide just filled the river down to North Woolwich at low tide. Then the resultant oscillation of any particle would be that distance, for, if any particles went more, others must have gone less. The mean motion must have been through that distance. He is now taking the tidal oscillation only, and will consider the displacement due to the upland water separately as more convenient, though the diagram has been calculated with it, 9443–50, 9452–4. He explains the diagram to the Commission, showing what the different lines represent, 9451, 9455–6. On Table 3 the horizontal oscillations are given in miles measured off the diagram, and his tidal oscillations are shorter than those observed by Mr. Baldwin Latham, being rather less than 11 miles in a spring tide and 7 miles in a neap tide, the difference being due to the fact that Mr. Latham's floats gave the motion of the central and surface parts of the water, and not exactly the mean motion of the water. The diagram is not affected in the least by any disturbance due to differential causes, such as eddies, &c., 9457–62. On referring to Table 3, it will be seen that the alteration of the height of the tide between the 14th and 22nd September gives a considerable displacement, which is also shown by Mr. Latham's floats. This was due to the tides decreasing from spring tides to neap tides, which caused a displacement up stream varying from 3,000 horizontal feet at Chiswick to 12,000 horizontal feet at Southend. When the tides increased from neap to spring tides there would be a corresponding displacement up stream, 9463–7. The column giving "the increase of the low-water volume" he inserted in the table to show that it is one of the causes that carries water up stream. The scale of the first half of Diagram 1 is a vertical scale, ten times as great as the latter half, and the figures on the horizontal lines represent distances in feet, 9468–71.

Diagram 2 represents the volume of fresh water flowing at each section of the river, including sewage. This includes the flow from Teddington, from the tributaries, and from the sewers. The principal importance of this diagram is to show how very small an influence the tributaries have, except the two affluents at Barking and Crossness, where the flow is increased considerably, 9472–6. The tributaries flowing in at different points of the river are shown by means of steps at the nearest place to where they enter the river, and the increased volume of sewage flowing at Barking on the 30th November is due to the influx of several tributaries which enter the Thames between Deptford and Barking, the Lea especially, which was flowing largely on that day. Generally, but not always, it follows that when the tributaries are in flood the Thames is in flood also, 9477–84, 9561–2, 9751–3. Diagram 3 shows the amount of displacement down stream at each section due to the upland water alone, neglecting the tidal oscillation. It is arrived at by dividing the volumes in diagram 2 by the areas of the sections. The Diagram is calculated for the 14th September alone, and it was done simply to show the way in which the displacement due to the upland water is diminished as you go down stream. The scale gives the miles per tide, and between Deptford and Erith the mean displacement is about $\frac{5}{8}$ths of a mile per tide, while at Gravesend it goes down to ·2 per tide, or $\frac{2}{3}$ths of a mile a day, 9485–98. The water coming over Teddington Weir on that day was about the average quantity. If it should be less than the average, then the displacement would be less, and *vice versâ*. The formula for calculating the amount of displacement owing to the water coming over is "the "displacement is directly as the volume," 9499–9502, 9700–21, 9766–8. The figures relating to the sewage flow he obtained from page 17 of Mr. Latham's report for 1881, where it is given as 13,603,000 cubic feet per tide, or 26,000,000 cubic feet per day, 9503–4. If the progress of the floats gave a mean down stream travel, they would agree with his diagram No. 5, but the down stream travel of Mr. Latham's floats is very much smaller than it would be according to this diagram, because they were kept to the middle of the stream, and were too short to reach down into those layers of water which move slowest. They therefore had a greater motion than the mean motion, and represent the motion

PROFESSOR W. C. UNWIN—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

of those parts of the water which are nearest towards the centre and towards the top, 9505–9, 9625–6. In all streams the surface has the greater motion, and the motion of the centre is greater than that of the sides. The motion in the centre and at the surface combined would therefore be considerably greater than the mean motion of the water, 9510–12. A slight alteration in the velocity either in the up stream or down stream travel will make a great alteration in the tidal displacement. About 4 per cent. alteration of velocity up stream will diminish the down stream displacement to nothing, while the same alteration in the down stream velocity would double the down stream displacement. To explain Mr. Latham's results, it is necessary to find out whether there was possibly such an alteration in the velocity of the float during its 12 mile travel up or down stream, 9513–14. He thinks it is possible that there is quite 4 per cent. more central and surface velocity during the flow of the tide than during the ebb, 9515. In the crooked parts of the river the whole stream twists upon itself, and the ordinary ratio of the velocity of the central and of the surface water to the mean velocity is very considerably altered. It seems probable that in these parts of the river the travel of the floats would be different from what it would be in the straighter portions of the river, which, if it is true, would account for the discrepancies in the progress of the floats, 9516–19. If there was no mixing action the travel of the sewage would be identical with the travel of the floats. As it is, owing to the mixing action, the sewage travels down quicker than the floats, because, in addition to the upland water which pushes it down, it is also pushed down by the sea-water which is left in the low-water volume after each tide, 9520. Diagram No. 4 represents the curves of saltness for three tides from data supplied to him by Professor Way. The vertical scale shows the number of parts of chlorine in 100,000 parts, and he has taken the quantity of chlorine in sea-water as 1,961 parts in 100,000. On the 14th September, at high water, the water at Erith was half as salt as pure sea-water, 9521–31. His reason for plotting this diagram was to show how greatly the quantity of upland water affects the position of the chlorine lines. Any increase in the upland water drives down the chlorine lines very much. The explanation of the saltness of the water on the surface being very slightly less than that taken at a considerable depth is due probably to the spreading out on the surface of the fresh water from the tributaries, and not all at once mixing with the water below. If there were no tributaries the mixing would be perfect at no great distance from Teddington, because the action of the mixing is so great, 9532–5. Diagrams 5 and 6 are to be taken together, and they show the amount of sewage in the river at the different places. By means of the chlorine analyses he is able to divide the water above Crossness into pure river water and water which has passed Crossness once, because it has a greater density than pure water, 9536–41. The vertical ordinate on the diagram at Teddington represents the section of the river, which is all fresh water there. The left-hand hatched line represents the whole river section. The whole of the cross-hatched part, including that marked sewage, is the quantity of Crossness water found by calculation to be in each section, and the dotted line with the hatched part to the right represents the area occupied by water which has been once at Crossness. The outer division represents the water which has never been to Crossness, 9542–52. Below Crossness the water in any section consists of water which has come up from the sea and water which has gone down from Crossness. Knowing the amount of chlorine in the water at Crossness and in sea water, he is able to tell from any sample the amount due to Crossness water, and how much has come from the sea, 9542–60. These two diagrams relate to Tables Nos. 6 to 11 inclusive, and depend upon no theory. They are a simple expression in volumes of Professor Way's analyses, and they represent the condition of the river at high and low water as indicated by the chlorine, 9563–7, 9732–8. Crossness water (by which he means the water which was in the river at the moment when the analyses were made) consists of river water, sea water, and sewage mixed. To find out the quantity of sewage there is in the mixture, three quantities, based on three equations, must be determined. First, the total quantity of salt in the mixture must be equal to the observed quantity

PROFESSOR W. C. UNWIN—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

of salt in the section. Secondly, the sum of the areas of the mixture must be equal to the known area of the section; and thirdly, the ratio of the river water and sewage water must be equal to the known ratio of the quantity of sewage and the quantity of upland water supplied in a tide respectively. The point to determine is the quantity or proportion of sewage in a cubic foot of water, and this he calls the sewage density, to which he has given values in his tables, 9568–79. Whenever the Crossness water goes up stream or down stream it carries with it the same proportion of sewage or materials which have been sewage. The tables and diagram show the distribution of sewage obtained by dividing the Crossness water into sewage, and water which is not sewage. In doing this, he has assumed that the sewage at the Crossness section bears the same ratio to the river water that the sewage supplied in a day bears to the upland water supplied in a day, and in order that that assumption may be right, he further assumes that the sewage is uniformly delivered into the river during the period of an ebb. As the tidal range contains the sewage of 12 to 15 days, the slightly non-uniform distribution of any one day's sewage very little affects the question. 9580–90, 9677–99. The entry of a pure stream above Crossness into the river is estimated as Teddington water in his tables, therefore it does not involve any error in his calculations; but a polluted stream entering above Crossness contains less saltness than the saltness of Crossness water, and is chiefly estimated as Teddington water; and therefore to the extent to which polluted water enters above Crossness the diagram shows less sewage than there really is in the upper part of the river, 9591–2. In addition to the state of the river as it actually was on the three days, he has calculated on the diagram an imaginary tide at low water, such as might occur in a period of excessive drought. He has taken the volume of upland water as being 30,000,000 cubic feet in a tide and 10,000,000 cubic feet of sewage. This would give at Crossness one cubic foot of sewage in five cubic feet of water. The quantity of sewage in other sections of the river he gives in Table 12. He has entered on the diagram an "Ideal low-water spring tide," which in a period of drought would give about 59 days' sewage in the river against 39 days on the 14th September, 28 to 31 days on the 22nd September, and about 12 days' sewage on November 30th. He has assumed that the saltness of the river from Crossness towards the sea would be the same exactly as on the 14th September, 9593–9607. Table 15 and Diagram 7 show the percentage of sewage, and the interesting part of that diagram is the way in which the per-centage of sewage is extraordinarily diminished upon the 30th November by the upland flood water. In connexion with that, the very great rise of the ideal spring tide line in drought at low water will be noticed, which is due to known diminution of the water at Teddington, 9608–10, 9776–8. The effect upon the sewage density, if the sewage was discharged at Gravesend instead of Crossness, would be to reduce the amount of sewage throughout the river to rather less than one half, but the bearing of that statement upon the inquiry is, that there is no point upon the river at which the sewage can be introduced which will keep the sewage entirely out of the upper part of the river, 9611–12. He wrote a book last year on "the "movement of water in a tidal river," and the calculations were based upon the Thames. In it he says, and he believes the statement to be correct, that the tidal action alone, independently of any mixing, effects no change in the material water of the river. It merely produces a comparatively short reciprocating oscillation of from 6 to 10 miles on a spring tide, and rather less upon a neap tide, 9613–21. Many people believe there is a more or less complete emptying and filling of the river at each tide, but this is not true, 9622–4, 9730–1. Table 1 was only a table of areas, and he did not think it was worth printing, 9634. He does not consider his method of calculating the contents of each division erroneous (viz., multiplying the mean of two sections by the distance between them). It is to his mind the most accurate method which can be adopted, considering the number of sections and the data at his disposal. The conclusions at which he has arrived are, under the circumstances, as accurate as any conclusions could possibly be from such data, 9635–43, 9757–61. For engineering purposes prismoidal rules would be more accurate, but he does not think they would be so

PROFESSOR W. C. UNWIN—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

accurate if applied to that part of the river which he has had to deal with, on account of the irregularity of its longitudinal sections. In depth between any two sections the Thames does not vary much, but its width increases sensibly, 9635–60. The whole of the canals in India have been taken out upon the plan he has followed, 9661, 9760. He is not aware that his method has produced a difference amounting to 25 per cent. between his results and those of Mr. Mansergh. Taking the section between Gravesend and Southend (which is the section in dispute), it is three-fourths of the whole volume, and there are only two cross-sections for this part of the river; the difference must be due to defective data therefore, and not to any defective calculation on his part, 9662–76, 9762–5. With regard to the belief of some people that the river empties and fills with the tide, the actual fact is that the volume of tidal water which enters at any one tide is about equal to the low-water volume. In simple words, the section of the river from Southend upwards is half filled and half emptied every tide, 9730–1. The volume brought in by the high tide from the sea contains the old sewage that has been carried down, and he has looked into the question of whether any Medway water enters the Thames at the same time. The drainage area of the Medway being one-tenth of the Thames, not more than one-tenth of the water in the estuary can have come out of the Medway, and he assumes that that tenth part, whether it is as impure as the Thames water, does not very much affect the question. The water that goes out of the Thames must, therefore, be fresh water which carries with it the same proportion of sewage. He concedes this fact, that up to 10 miles above Southend the water has come in from—he does not know where, but the water beyond that never goes out even of his part of the river at all. The salt which is found in the higher reaches of the river as far as Chiswick is, no doubt, due to the sea-water having worked its way up, 9731–44, 9771–5. He accepts Professor Way's statement that at Margate there was 12 per cent. of fresh water, and that it therefore contained a certain per-centage of sewage, because an enormous volume of fresh water goes out of the Thames daily, which does not become dissipated all at once, and a current of fresh water may have gone past Margate, 9745. Table 1 he hands in, as it is desired by Counsel, but Table 13 has never been printed. Table 14 embodies Table 13, and is in a better form, 9746–50. Before he began to consider the question of the disposal of sewage in the Thames he had made a large number of velocity and stream observations on the Thames at Putney and in the upper part of the river, 9751–6.

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SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—He has had considerable experience for some years upon matters connected with water and water pollution in the Thames, 9808. The Thames water is composed of river water pure and simple, sea water, and sewage, and it will be convenient to deal with these three classes separately at first, and take the mixture afterwards. By pure water he refers to that which comes over Teddington Weir, 9809–10. He has for many years past taken samples of the Thames water at West Moulsey, and for all practical purposes that water is the same as that which flows over Teddington Weir, 9811–13. He hands in a table showing the dissolved and suspended matters in samples of water taken from the Thames at Hampton, one foot below the surface on, or about the 15th of each month for the years 1874 to 1879. A few lapses occur because the samples were not taken in the middle of the month, and he has thought it better to keep his table uniform, 9813. The solid matter appears either in solution or in suspension. The matter in solution and suspension may be divided into organic matter and mineral matter; and the organic matter consists of vegetable or animal substances, 9814–18. The table refers only to dissolved and suspended matters, not to any mineral matter. When the water is "very slightly turbid" minute particles can be seen, but cannot be estimated. "Slightly turbid" means something more than very slightly turbid, and the water is said to be "turbid" when it contains less than or somewhere

MR. C. MEYMOTT TIDY—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

about one-tenth of a grain of suspended matter per gallon; that is to say, between one-tenth and one-quarter, 9819–20. The average of the river with regard to suspended matter varies a good deal according to the quantity of flood water, but from the table it appears that the quantity of suspended matter in the river at Moulsey is very small, and the turbidity of the water may be due to an almost inappreciably small quantity of suspended matter, as a very small amount will make water appear perfectly turbid, 9821–2. The total solid matter in solution in Thames water varies from 17 to 22 grains per gallon. He never knew it to be below 16 or above 23 grains. It varies at different times of the year, showing a perfectly well-defined wave in the course of the year, and the maximum or crest of the wave is reached about February; the wave can only be properly ascertained by taking a very large number of experiments, and his table refers to filtered water entirely. The lowest point occurs about August, 9821–30, 9833. The same law would apply in a great measure to unfiltered water, 9831. From February to August the quantity of chlorine in the upper part of the river is about $1\frac{3}{10}$ grains in a gallon, and from September to January about nine-tenths of a grain. The normal quantity may therefore be considered as one grain per gallon. It is very difficult to say to what cause the presence of chlorine is due in that part of the river, but all water contains a certain small quantity of chlorine in the form of common salt, 9832–7. The general constituents of the mineral matters are unimportant in considering the purity of the Thames water, but the chlorine and the total solid matter are important, and the magnesium is of a certain importance, 9838–9, 10,161–86. The only method of estimating the organic matter in the river is by the combustion process, that is to say, by the estimation of the organic carbon and of the organic nitrogen in the water. This was suggested by Dr. Frankland. The albumenoid process would not give any reliable results, 9841–2, 10,161–86. The organic matter varied from ·072 to ·256 grains per gallon in 1881, and the ratio of the nitrogen to the carbon (which together make up the total organic matter present) indicates somewhat the kind of organic matter present, that is to say, whether it is of animal or vegetable origin. The ratio of nitrogen to carbon is about one to eight, 9843, 10161–86. The proportion of ammonia in the river above Teddington is so small that for all practical purposes it may be taken as nil, 9844. It depends on the nature of the organic matter whether it is injurious to water. That in the Shannon, which is derived from the peat bogs, is not in the least degree injurious, and the water is some of the purest in the world, 9846. He tested the water for nitrates as well as for ammonia, and found (speaking from memory) two-tenths to three-tenths of a grain of nitrogen as nitrates per gallon, 9847–8, 10,161–86. For the last two years he made seven determinations daily of the free oxygen in solution in the water supplied to London. It varies from $1\frac{7}{10}$ to $2\frac{2}{10}$ cubic inches per gallon, according to the temperature, but generally the Thames water contains two cubic inches of free oxyge per gallon (or 277 cubic inches), 9848–51, 10,161–216, 10,616–21. When the ratio of nitrogen to carbon increases it indicates animal rather than vegetable contamination, which is infinitely more dangerous than vegetable contamination. Therefore, the larger the ratio of nitrogen to carbon, the more polluted the water becomes, 9852–3, 10,267–76. The composition of the Thames water above Teddington is singularly constant, and indicates water of a very considerable degree of purity. The suspended matter in the higher reaches is nearly always of the nature of clay and sand mixed with occasional particles of vegetable matter or fibre. The specific gravity of this suspended matter is about $2\frac{1}{2}$; it is very finely divided, and is very long retained in suspension, 9854–6. The quantity of free oxygen in the water is determined by a modification of Schutzenberger's process. Every tenth determination was actually done in addition in order to see how far it corresponded, 9857, 10,187–203. The organic carbon varies from ·103 to ·364 in 100,000 parts, and the nitrogen is an eighth of that, 9858–60. He has a diagram which gives the average results of about 1,200 analyses of the filtered Thames water, and shows the complete wave formed by the suspended matter in a year, 9861. He has examined the composition of the sea-water on a great many occasions, and the results confirm almost

MR. C. MEYMOTT TIDY—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

entirely those which have been arrived at by the Rivers Pollution Commission and mentioned in their sixth Report. He hands in a collection of Tables and Diagrams (*see* Appendix A. G.), 9862–3. He has inserted amongst the samples one of the Dead Sea water, which is curious from the fact that the nitrogen actually exceeds the carbon, viz., ·3 per 100,000 of carbon to ·4 of nitrogen, 9863–4. In all sea water the nitrogen is at a very much higher ratio than in fresh water. It may be taken at about one to one and a half. It is not by any excess of the nitrogen, but by decrease of the carbon, which is more easily oxidized than the nitrogen. At Southend, in October and June, the nitrogen was in excess of the carbon, 9865–9, 10,001–3. The amount of ammonia in sea water is almost nil, which is of importance in tracing sewage, and the amount of nitrogen as nitrates is also small. At Brighton the free oxygen in solution varied from 1·7 cubic inches to 2·1 cubic inches per gallon, which is much the same as in river water, 9869–75, 10,214–26, 10,616–29. With regard to chlorine, the amount varies considerably, as shown in the tables. The samples taken at Southend are perhaps the most interesting in connexion with this case, as they vary from 1,246 grains at low-water on the 16th October to 1,558 grains at high-water on the 10th June. From this it is found, in nearly all the samples, that the total quantity of solid matter and of chlorine is greater at high-water than at low-water. There is one exception to that, and he cannot explain it, in the case of Brighton in September 1882, 9876–78, 10,124–60. He made analyses in 1875 of samples of sewage taken at mid-day from ten of the large city sewers, and found an average of 94 grains per gallon of solid matter in each; 56 grains were in solution, and 38·15 grains were in suspension. Of that 94 grains, 31 grains were organic, 15 grains of which were in solution, and 16 grains in suspension. Night sewage varied from day sewage, not containing so much matter in suspension. Storm sewage varied from both. Exclusive of storm sewage, the general proportion of suspended matter in ordinary sewage contains about 25 grains per gallon. The average would be taking all sewage from 45 to 50 grains per gallon of suspended matter, 9879–83, 10,306–42. Storm sewage has been known to contain over 164 grains per gallon. It is due to the detritus of roads and accumulation in the pipes, 9884–6, 10,346–65, 10,667. The strength of the sewage in solution varies very much according to the time of day. It is at times strong, and at others weak; but as an index of the organic matter the organic carbon shows a maximum of about 5·4 and a minimum of about 3 in 100,000 parts. The average would be about 4·3 per 100,000. Organic nitrogen ranges from 3·8 to 1·3, and the average may be taken as about 2·5 per 100,000 parts. The ratio of nitrogen to carbon is as 1 : 1·77, which is very different from the proportion in pure water, and is more like that which is found in sea water, 9886–92, 9898, 10,267–305, 10,366–85. The quantity of ammonia in sewage is large, and varies from 6½ grains to about 2½ grains. (With the exception of nitrogen and carbon, which are given in parts per 100,000, he gives all his results in grains per gallon.) A fair average, taken from a number of samples not the mean of the two numbers, is about 3 grains of ammonia per gallon, 9893–5, 9933. The average amount of chlorine in London sewage is about 10 or 11 grains per gallon. The quantity varies considerably, and often reaches 10 parts in 100,000, but that really makes very little difference, 9896, 9900. To detect sewage in a mixture of pure water, sewage, and sea water, ammonia is decidedly one of the chief things. Free oxygen dissolved is also important, and he will discuss that presently, 9897, 9899. Of the London sewage, 80 per cent., or 37 gallons of water per head, represents the water supply. It is 10 parts per 100,000. This is from his own observation, confirmed by others, 9901–2. In calculating the amount of polluting matter which goes into the Thames, he has adopted the figures of Röder and Eickhorn, two great German authorities. From a large number of experiments, each person voids about 1,750 grains of fæces daily, excluding urine, which is equal to four ounces; 75 per cent. of that is moisture, and 25 per cent. or one ounce is dry matter. This is equivalent to 444 tons discharged daily into the Thames from a population of 4,000,000, of which 111·6 tons are dry matter, 11 tons of that being soluble, and 11½ tons insoluble, 9901–6. Of urine the amount

MR. C. MEYMOTT TIDY—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

is 376,605,555 gallons, or 1,681,274·8 tons are discharged into the river annually. The dry solid matter in urine amounts to 2½ ounces per head, which, added to the dry part of the fæces, gives 3½ ounces of dry matter per head per diem, which corresponds with Mr. Latham's estimate, 9907–11, 10,409–28, 10,439–54. This estimate does not include the other matters which go to make up sewage, and which contain more polluting matter than actual sewage, 9912–13. The insoluble matter which goes into the river floats about, and, no doubt, combines with the alluminous compounds from the alluvial mud which are raised by the tides and passing steamers, and so it is deposited on the bottom, causing, in his opinion, a very serious nuisance in the river, because it undergoes putrefaction and developes putrefactive gases. It is rendered lighter by putrefaction and rises again, and the offensive gases are given off to the air. It then sinks and the process is resumed. In the case of oxidation there is not much nuisance, as the products are not offensive. The soluble matter undergoes oxidation as far as it can, and as the quantity of oxygen in the water diminishes, so a less purifying power is found in the water, 9914–23, 10,481–9. On the 15th November 1879, when on the river with Dr. Frankland, the weather being frosty, he saw a rapid stream of sewage, calculated at from 20 to 30 million gallons (a day), flowing over the apron of the northern outfall at dead low-water. Owing to the amount of steam given off, the entire volume looked boiling hot, and from the bed of the river he noticed a bubbling up of gases indicative of the most active putrefaction. The smell was exceedingly foul. He noticed a similar thing going on in Barking Reach on the same day, and such a condition could only point to contamination with comparatively recent sewage undergoing decomposition. He is convinced from that and other inspections that, under certain conditions of water and of tide, a very great nuisance must undoubtedly exist, 9924–6, 9928–9. He is unable to give any reliable information as to the time sewage takes to putrefy, owing to the variable distance it has to travel as well as to the fact that the different kinds of putrescent matter present are influenced by different degrees of temperature, 9927, 9930, 10,109, 10,110. In order to arrive at some notion of the general composition of the river at different points, he divided the river into lengths, and personally (with two exceptions, Nos. 35*a* and 44) took samples from each division at one foot below the surface in mid-stream, to avoid any impurities floating on the surface. The results he has arranged in different tables and diagrams, and he hands them in (*see* Appendix A. G.), 9931–3. The river he has divided into the following sections, Teddington to Battersea, Vauxhall Bridge to Deptford, Greenwich to the Royal Albert Dock, Beckton to Crossness, and Erith to Purfleet, 9934 On the diagram all the results are shown in grains per gallon, except the organic carbon and nitrogen, which are shown in parts per 100,000, and free oxygen, which is given in cubic inches per gallon. On Diagram A. the numbers 1 to 58 correspond with the numbers of the samples taken, as shown on Table I. The numbers on the left hand represent the quantities per 100,000 parts of organic carbon and nitrogen, and the figures at the lower part of the diagram represent the cubic inches of free oxygen per gallon, as shown by the lines on the table, 9935–40, 10,366–70. In the first "reach" or "section," which extends to No. 25, the quantity of organic carbon is ·216, and the quantity of organic nitrogen is ·028 per 100,000 parts; the ratio of the nitrogen to the carbon is as 1 : 7·7, and the quantity of free oxygen 1·48 cubic inches per gallon. The free oxygen below Teddington is reduced very nearly by 25 per cent., but the ratio of nitrogen to carbon is practically the same. The water remains nearly as pure, but it is at the expense of the oxygen, 9941–8, 10,370–2. The tributaries are marked by spots in circles, and are placed on the line representing their junction with the Thames, but in a position on the scale to mark their degree of impurity instead of raising the Thames to that point on the scale, 9938, 9949, 9975–8. The ammonia is very little altered, and the matters in suspension in that reach average eight-tenths of a grain per gallon, 9950–1. The second reach includes the numbers 26 to 35, and in it there is a manifest increase of organic matter, the organic carbon has gone up from ·216 to ·323, and the organic nitrogen from ·028 to ·054 (or double the quantity) in

Mr. C. MEYMOTT TIDY—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

100,000 parts. The ratio of nitrogen to the carbon is as 1 : 6, and the free oxygen is reduced to 1·3 cubic inches per gallon. In this reach the call made on the oxygen is almost the maximum it can bear, and as a result the maintenance of purity is manifestly a difficulty, and at times no doubt it is impossible. He attaches great importance to maintaining full aëration for water, because he is quite convinced that, in effecting the purification of the river, the half inch of free oxygen in solution between 1·5 and 2 cubic inches is infinitely more powerful than that the half inch between 1 and 1·5; that is to say, that if a river has 2 cubic inches of free oxygen per gallon, and a purifying power of four, a river which contains 1½ inches per gallon has nothing approaching a purifying power of three, 9950–4, 9962–6, 10,001–3, 10,387–99, 10,611–15. The third reach extends from Nos. 36 to 42, and here the water becomes manifestly less pure; the organic carbon is doubled and the organic nitrogen quadrupled as compared with the last reach; the ratio of nitrogen to carbon is as 1 : 3, and the free oxygen is reduced to 0·7 of a cubic inch per gallon. That indicates that, owing to a continuous stream of impurity, the normal purifying action of the river is interfered with, and its power of reparation is seriously lessened, 9955–6, 10,001–3, 10,379–83. In the next reach (from Beckton to Crossness Reach), Nos. 43 to 53, there is a very large increase of organic impurity in the water. Thus the organic carbon is one-sixth greater than in the third reach, and 340 per cent. greater than in the first reach, while the organic nitrogen is 1,000 per cent. in advance of the samples in the first reach. The ratio of nitrogen to carbon is as 1 : 2·5, but the quantity of free oxygen is a little less, but not much, than in the previous reach. The importance of this fact is that by a constant pouring in of sewage the self-purifying power of the water is practically reduced to a minimum. Its power is exhausted, because the sewage is poured into a mixture of salt water (which is antiseptic), and water in which there is practically no oxygen on account of the quantity of sewage already in it. The sewage, therefore, to a great extent remains in its original condition, 9957–61, 10,001–3, 10,376–80, 10,384–6, 10,677–8. The Ravensbourne, which enters the Thames at the beginning of this section, is purer than the main river, 9967–8. In the last section, from Erith to Purfleet, the organic carbon is ·718, the organic nitrogen is ·176, the ratio of nitrogen to carbon 4·0, and the quantity of free oxygen ·508 cubic inches per gallon. He is quite unable to explain the alteration in the ratio of the nitrogen to carbon. He has determined the quantity of ammonia which is given in the large table, but the estimation of ammonia is not a very accurate thing, and for this reason it would have been better if the analyses for ammonia and free oxygen could have been made at once on the river, and so have avoided shaking and the access of air to the samples, 9969–74, 10,373–5, 10,404–8. He wishes to correct an error in the table in which the free oxygen of the Wandle is put down as at ·01 instead of ·1, 9979–81. He hands in the analyses of water taken at Allhallows Pier (*see* Table 13, Appendix A. G.). Evidence he believes has already been given respecting them, and he has no remarks to make on them, beyond that they are confirmatory of the other observations, 9982–6. The samples taken at the northern outfall at Barking were not taken by him, and Table No. 5 shows very little, as the samples, on analysis, show that it was not pure sewage, but a mixture of sea water, sewage, and river water. Some had a strong sewage odour when taken, others developed an offensive odour after being kept. The quantity of free oxygen in the samples is worth noticing, as it would not exist if it was pure sewage, 9987–9. As the outfall at Crossness is below the level of the river, the samples taken there must contain a mixture of sewage and sea water, and it was hardly worth while taking them at all. He hands in the analyses (*see* Table 6, Appendix A. G.), 9989–92. He hands in the analyses of the samples taken at Beckton (*see* Table 7). He took samples of the actual sewage itself on the dates mentioned in the table, to see how far the Thames was polluted by the discharge. Sea water to a considerable extent was mixed with the sewage, and the amount of organic carbon and organic nitrogen is comparatively small. The quantity of ammonia present was very large, but this is due to the slight leakage from the gas works, which cannot be prevented. The ammoniacal liquor

Mr. C. MEYMOTT TIDY—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

the Gas Company converts into salts of ammonia, so it is against their interests to allow it to run to waste. He found some chlorine also in the samples, which indicates some backward flow of sea water, 9992–9. The suspended matter at Crossness is considerable, and the samples, which are purer sewage than the others, contain an average of 30 grains of suspended matter per gallon, 10,000.

He has examined some thousands of the deposits in the various waters of the Thames microscopically, and in doing so examined the samples as they were, and also employed hæmatoxylin as a staining fluid, 10,005–6, 10669–75. The system he adopted was, first, to collect the whole of the deposit from a water sample, and mix it with distilled water (he did not filter it), so that the mineral deposit should sink, leaving on the surface the lighter and flocculent organic matter. In all the cases, where possible, he took a duplicate sample, and added a solution of hæmatoxylin to bring out more distinctly the animal tissues. Before doing this, however, he examined the appearance of fæcal matter, and a water in which fæcal matter, mixed with other mineral matters, were added. The basis of his work was a recent publication of the researches of Professor Nothnagel, in which it is pointed out that the substances of almost, if not, constant occurrence in fæcal matter were—

1. Muscular tissue.
2. Yellow elastic tissue fibres.
3. Shreds of fibrous substances, such as fasciæ, and
4. Spiral and free vegetable cells.

Of these last he has a good deal to say, 10,005–10. The mud when taken from the bed of the river has in the majority of cases an absence of smell, but when kept in a warm laboratory the smell readily becomes very offensive. This is probably due to putrescent matters undergoing decomposition. Another characteristic of sewage deposit is a flocculent and ill-defined surface, whereas in a non-sewage deposit the surface is perfectly smooth and well defined, and the supernatant liquid is fairly clear. The dimness of the sides of the glass is also a very marked feature of the observation in the case of sewage, 10,011–16, 10,082–3, 10,669–75. He commenced his microscopical observations in 1879, and has carried them on to the present time on every description of samples, 10,017–18. As regards muscular tissue, fragments of muscle with distinct striation are constantly found in fæcal matter, but rarely in sewage mud and deposits. This is due to the fact that striated muscle rapidly undergoes decomposition, and that loss of striation is amongst the earliest signs of decomposition. Where this occurs it is practically impossible to identify muscle in the mixed solution. He hands in some chromo-lithographs to illustrate the appearance of some of these specimens under the microscope, 10,017–21, 10,055, 10,090–2. The yellow elastic tissue is exceedingly important and exceedingly characteristic of sewage, because, unlike muscular tissue, the fibres resist putrefaction to an extraordinary extent, but they also resist the action of very strong chemical solvents for a very long period. They become clearer, when found, from having passed through the alimentary canal, and from the action of the water. These fibres are very frequently met with in muds, and also in the deposits near the outfalls. He never looks for the striated muscle now, as he knows how readily it disappears, 10,022–6. Shreds of fibrous substances are very often met with, and they too resist decomposition for a very long time. Particles which probably make up the tendonous and fascial tissues are often to be found near the outfalls. He has found them in samples under the microscope, 10,027–30. The fourth division is the spiral and other vegetable cells and appendages. This is a matter of the utmost importance. The appearance of vegetable matter and particles of vegetable cuticles are of no importance in determining the fæculent nature of any deposit, but there is a very great peculiarity in the vegetable matter which has passed through the alimentary canal by setting free the solitary vegetable cells or more especially the spiral vessels. Plate 3 shows that the free spiral vessel has no investing membrane round it. It is very difficult to decompose it at all. The spiral cells cannot be mistaken, as they are as definite as possible, and are perfectly clear, there being no hazy outline about them, 10,031–8. He has found hairs of

MR. C. MEYMOTT TIDY—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

wheat and other cereals constantly in the sewage mud, which at first he took to be broken bits of diatoms, and occasionally he finds starch cells, 10,039–42. One of the most characteristic features of fæcal deposit is the yellow amorphous matter. It is entirely different in appearance to non-sewage mud when seen under the microscope, as it resembles portions of disintegrated muscle and matter from the dissecting room, which have been in the water a long time, while a non-sewage deposit has a perfectly definite appearance, and consists mainly of a number of sharp particles of angular shape which are highly refracting, and evenly cover the whole field, 10,043–51, 10,669–75. The particular feature of vegetable decomposition is a coarse sort of breaking up. It is difficult to express what takes place, it is in large pieces, and nothing like the amorphous granular material distinguished by the breaking up of animal matter. He has no doubt that the yellow amorphous matter is of animal origin, but has wondered sometimes whether the yellowish material may be due to bile in any way, 10,052–4, 10,669–75. He has found living organisms present while decomposition is going on, and has examined them, and has examined into the diatom, the shells of which are found in nearly all the cases of sewage mud. In some of the mud the diatoms will be found in active motion, but they are not so frequent in non-sewage mud. He has never been able to connect diatoms with the sewage, and it is equally difficult with respect to the animal life which is generated under those circumstances. It is very difficult to deal with the question of living organisms, and he cannot distinguish between those developed in vegetable and in animal matter. With regard to young vegetable cells, the cell loses its characteristic aspect the moment its cell wall breaks, but this would not account for the yellow amorphous matter, 10,056–60. On Plate A, fig. 2, there are some yellow masses, quite distinct from the yellow amorphous material, which are nearly always found in sewage deposit, and are undoubtedly of animal origin, because there is an entire absence of vegetable characteristic about them, secondly they present the precise aspect of disintegrated animal tissue, and, thirdly, because he has found several times pieces of muscular tissue at one end converted into a yellow mass on the other, *see* fig. 2 c. He found a specimen of this in the mud at Barking outfall, and he thinks distinctly that it is an adipoceratous condition, 10,061–5, 10,669–75. In fig. 3, Plate B, a portion of tendon or fasciæ found in a water deposit collected at All Hallows Pier is shown converted into a yellow mass, 10,066–7, 10,669–75. Where sewage is found, perfect fusiform diatoms are invariably found. He does not think so much of them now as he did at the time of the Mud Inquiry. They may have something to do with the question, 10,068–9. He now directs attention to Table A, figs. X and Z, which represent a sample of sewage mud and non-sewage mud. If any of the decomposition was due to bodies of animals, the decomposition would appear *en masse*, and hairs of animals would be found more frequently in the river; but in the numberless deposits he has examined he has only found a hair but once, and that belonged to a mouse. (He has heard that at Bedford the pumps have been choked by hairs.) Hair is very indestructible. From this the inference may be drawn that the decaying matter comes from the sewage deposit, and the constancy of the appearance along the river suggests to him a constant supply of the material, 10,070–7, 10,109. He has found cotton and woollen fibres, house flannel fibres, and many other things, too numerous to mention. He has no doubt that amongst them he has met with blood cells. The absence of hair is to him a very astonishing thing. Fragments of dead worms he has frequently seen, but is unable to say what sort they were, 10,078–81. He is able to trace the distinct characteristics of sewage mud by their changing their character. Firstly, as the sewage goes down the river, the solid constituents, by reason of their different specific gravities, undergo a process of sorting, the lighter particles being carried farther than the heavier particles. The yellow fibrous material drops out first, and is lost in the further deposits; then the spiral vessels drop out, leaving the yellow amorphous matter as the last remnant of sewage in the deposit. The appearance of these two bodies in conjunction is very important, because the spiral vessels are of vegetable

MR. C. MEYMOTT TIDY—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

origin, and it indicates almost absolutely that the material has passed through the alimentary canal; and the yellow amorphous matter is of animal origin—so you get a combination both of animal and vegetable origin indicative of sewage, 10,084–8. Although the microscopic evidence is in no sense quantitative, it is in some wise relatively so, for instance, he has found spiral vessels at Hammersmith rarely, but occasionally at Battersea. At Deptford they are fairly frequent, and as he is unable to give the numbers for these places, they must be taken generally. He has never found spirals at Teddington. He further explains his meaning by reading extracts from his notes on the examination of the suspended matter in the water, 10,097–100. 10,111, 10,602–6. It is difficult to say whether the organic matter in the mud keeps pace with the number of particles in the microscope, and whether the quantitative determinations of nitrogenous matter increase as you get nearer to the outfalls in the same way as the various particles increase, he would not like to say, off-hand, 10,101–2. He does not think the quantity of organic matter in the mud conveys much: it is rather the kind of organic matter that is important. He would prefer to regard the relation of nitrogen to carbon as the more important element in determining the character of the mud, 10,103. He has no doubt in his mind that the Thames in the higher reaches is being rendered impure by the outfalls of the Metropolitan Board of Works. The discharge of 400 tons of material every day into the river cannot do otherwise than foul it, 10,108. The smell in the water is partly due to the reduction of sulphates, as a result of which sulphides are formed, the action of carbonic acid on which sets free sulphuretted hydrogen. With regard to the absence of hairs, he now is of opinion that none of any size would pass through the pipette, 10,109. In making his experiments, he allowed the samples of mud to stand in some cases 24 hours before drawing the floating matter into the pipette, but whether the flocculent matter was one per cent., or more, or less, of the total suspended matter, or what percentage of sewage was in the mud, the microscope gives no information whatever, 10,112–18. Nor does it give any information as to the age of the sewage beyond the fact that the presence of striated matter indicates sewage of the most recent deposit; and so on, 10,119–20. He has traced the yellow amorphous matter as far as Chiswick in suspended matter, but at the Mud Inquiry he had traced it as far as Teddington in mud samples, 10,121–3, 10,607–10.

He has confidence in the accuracy of his determinations of chlorine to the extent of 2 per cent. He is quite ready to admit an error up to that amount, and is certain that on the 10th June 1882 the water at Southend contained 1,558 grains of chlorine at high water, although he cannot explain it. He made the analysis himself. On the 28th January 1882 the water in Mid-Atlantic contained only 1,261 grains, 10,124–44. 1,558 grains per gallon is equal to 2,225 parts in 100,000, and 1,961 grains of chlorine would equal 2,581 grains of salt, which would represent almost the entire solid matter contained in a gallon. This does not represent common salt, but would include chloride of magnesium, 10,145–50. At high water at Southend he would not expect to find much fresh water. He has not considered the question of fresh water coming into the river from below Southend, and has worked entirely from his own experiments without any comparison of the Engineers' tables. His dates do not synchronize with their dates, and he would wish to think over the matter before answering questions on the subject of fresh water at Southend, and his analysis of the salt in the water there 10151–60. As regards the process for obtaining the amount of free oxygen, he believes that the old process is not so reliable as the present one. The analysis used to be made with a Cooper's tube, but now he measures the oxygen in one of Dr. Frankland's gas apparatus. The Schutzenberger process gives a slight error, but it is not of any moment, 10,187–203. The oxygen in solution never falls so low as 1·1 at Teddington in the summer by the new process, the average in January 1882 from a series of experiments being 2·18, in July 1·77, in August 1·78, and 1·85 in September, 10,206–16. If the quantity of free oxygen in sea water was less than that in river water, there would be a gradual diminution in the oxygen as you went down the river,

Mr. C. MEYMOTT TIDY—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

but his observations have led him to say it is not less. At Southend Pier, at high-water, his analysis shows that the amount of free oxygen is 1·39 at the bottom and 1·31 at the surface, and it is perfectly manifest that on the day the samples were taken there was less free oxygen at Southend than at Teddington; and, as he has said before, the only sea water he has tested for oxygen was at Brighton, which gave a result varying from 1·7 to 2·1 cubic inches. There are very violent fluctuations in the amount of free oxygen without any apparent cause, and these he has shown in his tables. For example, at Chiswick and Erith there are very remarkable variations, and the results he has obtained at Erith from the water have been in many cases very incomprehensible. If the inferences were drawn from a single place or determination, his reliance on the influences and deductions from the tables would be shaken, but in recording the analysis you cannot take one single thing and draw deductions from it, 10,217–40, 10,626–45. It is quite possible that when his samples of water stood for 24 hours before being analysed oxidisable sewage matter would take up a certain quantity of free oxygen, but if the bottle was quite full and the stopper put in so as to prevent any shaking, the oxidisation in the bottle would be reduced to a minimum, 10,241–44. In some experiments he made on the Shannon water, into which some sewage (organic matter) flowed, he made an analysis on the spot of one sample, and then made another analysis of a similar sample when he reached home. There was a difference in the amount of free oxygen; in the latter case it was less than in the former, but the difference made no alteration in the first place of decimals. If a bottle is not filled, and is shaken about and taken home, there is a difference. One reason why sewage in a bottle oxidises more slowly than in the river so long as there is oxygen to take up is, that it is not possible in a laboratory by shaking up a bottle to imitate what goes on in nature; there is no vegetation in the bottle, and you lose the chance of setting free oxygen in a somewhat hyper-active condition, 10,245–55, 10,622–25, 10,666. There is no doubt that fresh sewage matter does oxidise, and in so doing necessarily takes up oxygen from the water of the river, therefore, when a diminution in the quantity of oxygen is found below where the sewage is placed, it indicates the burning of the sewage. And, again, if there is a small quantity at one place, and more lower down, it either means that the water coming in has contained a large quantity of oxygen, or that the river is recovering itself and becoming more oxygenated, 10,256–61. While quite admitting that the diminution of oxygen in the Thames may materially influence fish-life, although he does not know the quantity of oxygen necessary to maintain fish in water, yet he considers the setting free of the sulphuretted hydrogen from the reduced sulphates of the sea water, which sets free a noxious gas, is itself infinitely more deleterious to animal life than the mere reduction of free oxygen, 10,262–66, 10,676. In calculating the average results from the samples taken from the City sewers (*see* Q. 9879 *et seq.*), he took the simple arithmetical mean of the figures without considering the length or size of the sewers, and at that time he had not seen Dr. Letheby's tables, he only referred to the laboratory book. He is afraid his results are not absolutely reliable; he does not put them forward as such, for no results can be absolutely reliable, he is sorry to say, 10,306–41. Omitting storm sewage, the sewage delivered at Barking and Crossness contains an average of about 25 grains to the gallon. This may be called normal sewage. At the time of the mud inquiry he stated that it contained 22 to 23 grains, but he should have said about 24 grains, or 23 to 25 grains, 10,342–46 The proper way to take the samples would have been to have a series of people along the river taking them simultaneously, but that was impracticable. He therefore took them himself on different days, as nearly as possible at the same time, viz., at about half-way between high and low water, with a few exceptions, 10,370–83. The sample taken at Beckton, being actual sewage, is not a fair sample, and he would not have inserted it in the table, had it occurred to him, 10,384–7. That which renders the water emphatically the most impure is that which is present in the form of soluble matter. You must not judge of the purity or impurity of the water by the amount of suspended matter, 10,400–1. He cannot account for the comparative absence of free oxygen

Mr. C. MEYMOTT TIDY—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

in the section from Putney to Vauxhall; it is very remarkable. The variations may be caused by the constant contest going on between the organic matter and the oxygen, 10,402–3. His figures relating to the dry fæces voided by the population he took from the works on the subject by Röder and Eickhorn, as well as from Messrs. Woolff and Lehmann, the latter being the original authority. On considering the matter, he feels bound to admit an error in the quantities which reduces the total of moist fæces from 444 tons daily to 385 tons; the dry fæces from 111 tons to 97 tons; and the solid matter in solution will be 197 tons instead of 282 tons, 10,410–38. He has not considered the extent or the dilution the sewage undergoes, because it is not (in his opinion) an important question. It is simply the addition of sewage to sewage. If it was the addition of sewage to fresh water, then the question of dilution would be important. He will assume, but will not admit it, that the sewage is discharged into a volume of liquid 240 times its own volume, and it follows, therefore, that the suspended matter comes to one-tenth of a grain per gallon. As a chemist, he has made no calculations whatever of the amount or percentage of the sewage in the river, considering it to be entirely an engineering question, 10,455–80. The pamphlet which he published, "On River water," and his remarks on the pollution of rivers by sewage, are not applicable in any way to the Thames at Barking or Crossness, because he referred to pure water and to non-tidal rivers. The Thames at Barking contains a large quantity of salt, which possesses preservative or antiseptic qualities; the oscillation of the tides carry the sewage backwards and forwards, so the sewage daily is discharged into water which is itself a kind of dilute sewage; and, further, there is a comparatively small quantity of free oxygen in the water where the sewage is discharged into the Thames; whereas in a stream which is not tidal, vegetation is found which sets free a quantity of oxygen. It is well known that a small quantity of oxygen has not the same activity that a large quantity has, and when in a nascent condition (*i.e.*, when set free by plants) it has an activity which it does not possess afterwards, 10,490–529, 10,651–65. Oscillation is adverse to the process of oxidation to this extent that there is not the same amount of purity kept up, 10,530. The Irwell, one of the rivers he referred to in his pamphlet, is more polluted where the sewage comes in than the Thames, but its colour is due to the dye-works. By "pure" water he refers to water unpolluted with sewage, and the Irwell is not so polluted at the point where the sewage enters. Vegetation exists in the Irwell below Manchester, and so the process of purification goes on, 10,531–42. Oxidation is more powerful in summer than in winter, owing to increased vegetation and light, 10,543–51. The oxygen in the river below Purfleet increases, having completed its work of burning up the sewage, if any arrives, at Southend to a certain extent; and it is due also to the oxygen in the sea water which comes up the estuary of the Thames, 10,552–72. In the former inquiry he stated, in answer to questions put to him, that "a large portion" of the sewage was oxydised or burnt up before it reached the outfalls. He should have said that "a portion" had undergone a primary putrescence, and he wishes it to be understood that, although he adopted the phrase as put to him, he now modifies the statement, because oxidation is totally distinct from putrefaction, 10,573–82, 10,592. In his opinion, the nitrogenous matter in fresh sewage is not converted mainly into gaseous matter when it reaches the outfalls, nor is there any conversion into gaseous matter in the sewers that is worth mentioning, but in the sewage there are matters of varying putrescence; for instance, the primary putrescence going on will convert the urea into carbonate of ammonia, which does not evaporate. Another thing he has noticed is that the smell from the sewage was strong in some parts of the sewers, and that it would cease for a period and be found again in another portion, 10,583–91. Not having studied the matter, he is unable to say whether the condition of the river or the emanations from it are injurious to health, but throwing 400 tons of sewage into the river undefæcated, when the whole of the solid impurity could be so easily removed, and the effluent made just as pure as the normal condition of the river, must produce a mass of emanations which he would think, from *a priori* reasoning, must be injurious to health, 10,593–601. In

## Mr. C. MEYMOTT TIDY—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

a sample of water the quantity of ammonia is less by the time you get home than when first put in the bottle, it either evaporates or becomes oxidised, therefore any details regarding it fall short necessarily of the actual facts, 10,646–50. The discharge of sewage into the Thames between Lechlade and Teddington does not cause the same nuisance as if it was poured in at one spot in a vast mass, because the sewage is now spread over a distance of 150 miles, and comes in at various places, leaving considerable distances in which the water can become pure once more, 10,654–57. He has not yet completed the promised analysis of the wells at Grays, but the quantity of salt in the Grays water is 13 grains, 10,668. He wishes to add that in making his experiments the troughs were all very carefully washed before making the analysis. There was no leakage that he was aware of, and he examined the glass to see that there was no foreign matter attaching to it. With regard to his remark that a great many of his results went against the theory of oxidation, he explains that his work was done out of doors, and in consequence of the difficulty of keeping the "blacks" out, he got no reliable results for some time, 11,277–9, 11,556–7. He hands in a photograph of the apparatus used by himself in his oxidation of sewage experiments, and explains it in detail. The amount of care he took, and the amount of labour expended in making these experiments, can hardly be imagined, and they have never been answered to his mind, 11,556–7. He points out that his statement in his pamphlet on the condition of the Irwell nine miles below Manchester is correct, and not incorrect, as stated by Dr. Frankland. "*The Stream*," he says, at Warrington has lost its offensive appearance, 11,556. He differs from Dr. Dupré's statement that the smell from the sewage is lost at a distance of 1,000 yards from the outfalls. It can be smelt at a very much greater distance, 16,227. He also denies having suggested that the fact of the oxygen having fallen below the standard amount is an indication that the river has lost its power of oxidation, 16,067–8.

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The insoluble matter which goes into the river floats about, and combines with the albuminous compounds from the alluvial mud that would be raised by the tides and passing steamers. It would then be deposited at the bottom of the river, and it undergoes putrefaction. Gases develop and cause it to rise again, when the putrefying gases are given off to the air, which are most offensive. The insoluble matter then sinks again to the bottom, when the same process is repeated. This insoluble matter is a very serious source of nuisance to the Thames, 9914–19. He hands in an analysis of samples of mud supplied to him, which, owing to the quantity of organic matter, as well as the quantity of nitrogen and phosphoric acid which they contain, he has no doubt contain sewage, and clearly were taken from the Thames at different points. The samples were all dried at 230° Fahrenheit, at which temperature all water deposits and things of that kind are dried, 10,093, 10,094, 10,105–7. The quantity of organic matter was ascertained by burning; the ratio of nitrogen to carbon is estimated directly. As far as chemistry is concerned, he has no doubt that the mud samples contain sewage, without stating anything about the proportions, 10,095–6. He differs entirely from Dr. Dupré's statement that the mud in the neighbourhood of the outfalls is not worse than the average mud of the river. It contains very much more sewage than Dr. Dupré makes out. There is an amount of nitrogenised matter in it which has not been oxidised, and which may undergo putrefactive decomposition when exposed on the mud. Putrefaction is not oxidation. When oxidation takes place harmless inoffensive bodies are formed, but when a body putrifies it is broken up and offensive gases are given off. In the case of oxidation the hydrogen becomes water, and the carbon becomes carbonic acid. A small quantity of the organic matter in the mud very likely is oxidised, but the tendency is to break up and decompose into other products. The mud would then smell, not necessarily at once, but in a few days. It is possible for oxidation to go on while putrefaction is also going on, but not upon the same particles, 16,228.

## Professor EDWARD FRANKLAND, Ph.D., D.C.L., F.R.S.

Professor of Chemistry in the Normal School of Science and Royal School of Mines, and Past President of the Chemical Society and the Institute of Chemistry.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He has known the Thames since the year 1845, and in 1868 he was appointed a Commissioner to inquire into the pollution of rivers and the best means of remedying it; the inquiry lasted for about six years, 10,681–3. In the year 1845, and since then, he has been in the habit of crossing the Thames twice daily, and has always taken notice of the condition of the river, 10,684, 10,977–11,005. The river, as it passed through London, diminished in purity until the opening of the main drainage outfalls. It improved for a time, but it has now become impure again, 10,685–6, 10,977–11,005. He has made several inspections of the river between Teddington and Erith, and at Teddington, popularly speaking, the river is there a pure unpolluted stream, 10,687–90. He remembers being on the river with Dr. Tidy one day at dead low water, when, to his surprise, he saw a very large volume of sewage being discharged into the river, which he estimated at between 20,000,000 and 30,000,000 gallons in 24 hours. There was a very offensive smell arising from it, 10,696–9. In 1882 he received 20 samples of water from Dr. Collingridge. They were labelled as having been collected on the 14th September, and were divided into two sections, one of which was collected at high and low water respectively, the other being taken near the surface and near the bottom at the different stations, which were as follows, viz.:—Teddington, Chiswick, St. Paul's Pier, Deptford, and Barking. He analysed the samples, the results of which appear on the tables and diagrams handed in by Dr. Tidy. (*See* Appendix A. G.) Dr. Tidy and Professor Way had similar samples sent to them, and although he has seen their results, he conducted his analyses independently of those two gentlemen. He also received some samples on the 22nd September 1882, taken at neap tide at the same places, with the exception of Barking, North Woolwich being substituted for it. Tables Nos. 11 and 12 refer to these two sets of samples, as analysed by himself, 10,702–14, 10,750. Table No. 13 refers to his analysis of the samples taken at St. Paul's Pier only from the 28th October to the 11th November 1882, 10,715–22. Diagram B. shows the ratio of nitrogen to carbon in the samples taken on the 14th and 22nd September, based on the combined tables and results of Dr. Tidy and himself. The results throughout are expressed in parts per 100,000. Diagram C. relates to the samples taken at St. Paul's Pier and at Erith upon the same days. He is responsible for the former analyses, and Dr. Tidy for those at Erith, 10,723–8. From these results he draws the following conclusions, that in spring tides sea water makes its way up to Chiswick, but not to Teddington, and that wherever sea water is found there is evidence of the presence of sewage in the increased proportion of ammonia and of nitrogen in the dissolved organic matter, 10,729, 11,109–28. He attaches great importance to ammonia as indicating the presence of sewage, but it is unfortunately a very evanescent substance, so it is difficult to say how much sewage there may have been in a sample on this account. The sewage results from ammonia may therefore be taken as the minimum, 10,729–32, 11,006–12, 11,109–28. There is very little ammonia in the river at Teddington, and practically none in sea water. When found in the Thames there are no sources of importance from which it could come other than sewage, 10,733–5, 11,096–108, 11,233–6. In those samples from which sea water is practically excluded the increase in the proportion of nitrogen to carbon indicates the presence of sewage matter, but if sea water mixes with the polluted river water, the evidence cannot be trusted, because sea water contains organic matter even more highly nitrogenous than that in sewage, 10,736–7, 11,006–12, 11,141–51, 11,233–6. The character of the suspended matter varies very irregularly in different parts of the river. It is sometimes chiefly animal, and sometimes chiefly vegetable, as indicated by the proportion of nitrogen to carbon in it. It is worthy of note that a large proportion of the suspended matter is vegetable, although nearly the whole of the dissolved organic matter is animal, being the constituents of urine, which makes a river more foul than the fæces, 10,738–42. On page 27 of the first report of Sir W. Denison's Rivers Pollution Commission this is clearly

stated, 10,741–5. Dissolved organic matter in ordinary river water is non-putrescible, and contains an average proportion of nitrogen to carbon of 1 to 7; dissolved organic matter of sewage contains an average proportion of 1 to 2; in sea water the ratio is 1 to 1·75; while in a mixture of sea water and river water with sewage it is impossible to tell whether the highly nitrogenised organic matter is derived from the sewage or the sea water, 10,746–8. The presence or absence of sea water is ascertained by the presence or absence of chlorine, and in many samples, that there was little or no sea water, is evidenced by the low proportion of chlorine in those samples, 10,749, 11,233–6. On the 14th September the ratio of nitrogen to carbon at St. Paul's Pier in the top sample was 1 to 3·1, and in the bottom sample it was 1 to 3·6. At Deptford the ratio was 1 to 3·2 on the top, and 1 to 4·9 in the sample taken 18 feet below the surface. The difference of 15 minutes between the taking of the low-water samples would hardly affect the ratio, though they might have been taken quicker. The high-water samples undoubtedly were taken at the same moment, 10,750–3. The proportions of chlorine were only 4·06 in 100,000 parts at St. Paul's Pier, and 48·9 in 100,000 parts at Deptford, both being low-water proportions. The small proportion of chlorine makes the ratio of nitrogen to carbon of importance. These results he obtained from Professor Way, 10,753–5. At North Woolwich, on the 22nd September, at low water the proportion of nitrogen to carbon at the top was 1 to 2·5, and at 20 feet below it was 1 to 2·3; chlorine in both samples 8·3 per cent., 10,756–8. He applied that standard to the samples taken at St. Paul's Pier between 28th October and 11th November, and these samples are very interesting as showing the very different condition of the river which prevails at different times (*see* Table 16). The analyses show that upon these occasions there was no appreciable sewage in that part of the river. It is due, he thinks, to the flow over Teddington Weir, which by the gaugings give for that time an average flow of 5,772,000,000 gallons daily, while the average flow is only 800,000,000 gallons daily, 10,759–63. The quantity of ammonia was ·046, 10,764. Ammonia is a good affirmative standard, but not trustworthy as a negative one, 10,765. Judged by that standard, he found undoubted evidence of sewage in the river at Blackfriars Bridge and at Beckton on the 11th July, and at the Monument and several other places above the northern outfall on the 20th and 21st June. He deduced this from the ammonia in the table of results (No. 11), 10,766–9, 11,013–19. Tables Nos. 11, 12, and 16 are his own, the rest are Dr. Tidy's, 10,769. On the 11th July the quantity of ammonia in the sample at Beckton was 3·28 per gallon, which is a little more than the average. The proportion in unmixed London sewage varies from 1·711 to 6·527 grains per gallon, the average being 3·013 grains. This ammonia he believes to be due to a stream of sewage which must have been flowing up the river near the bank on that day, 10,770–6, 10,787, 11,013–19. On the 14th September, at Chiswick, his analysis shows an abnormally high proportion of ammonia, indicative of a slight admixture of sewage. Sewage was unmistakeably present at St. Paul's Pier on the same day, and on the 22nd September it was present in the Thames at Deptford and North Woolwich to a very appreciable extent. After deducting the ammonia due to the Teddington water, the amount at North Woolwich was ·199 of a grain per gallon one foot below the surface, and ·109 of a grain 20 feet below the surface, 10,777–86, 11,233–42. Taking the average quantity of ammonia in the London sewage as the basis of calculation, the numbers he has just given for North Woolwich correspond to 6·61 gallons of sewage in each 100 gallons of Thames water at the surface, and 3·58 gallons of sewage in each 100 gallons of water 20 feet below the surface. He considers that these proportions of sewage are very serious indeed as being present at that part of the river, 10,788–91. At Allhallows Pier the water, on the 16th August, indicated an appreciable percentage of sewage from Dr. Tidy's analysis, 10,792–4. Between the 28th October and 11th November the amount of sewage at St. Paul's Pier was practically nil, though there was abundant evidence of its presence at Erith, 10,795–6. In his opinion the river is rapidly becoming worse, partly from the greater amount of sewage discharged into it, owing to the increase of population in London, and partly from the

PROFESSOR EDWARD FRANKLAND—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

accumulation of mud banks, which are increasing from year to year, even as far up as Westminster; they putrefy in warm weather and create a permanent nuisance, 10,835–40, 10,977–11,005. In 1859 he recommended deodorization of sewage to the Metropolitan Board of Works, but that deodorization has not been carried out, 10,841–3. Sewage matter is got rid of very slowly by oxidation in running water, 10,859–61. He has made careful and repeated experiments upon the River Irwell, just below Manchester, below all the sewer outfalls and all the factories, and just before its debouchement into the Mersey, which takes place above Warrington. The samples were taken on the same day, but time was allowed for the river to flow from one place to the other, and they were then compared with each other. Between those two points, a distance of 11 miles, the river falls over six weirs, a total height of 34½ feet. This fall covers the water with foam for hundreds of yards below each weir, so that it gets very well aërated at each of those weirs, 10,862–6. The purification from suspended matter by subsidence was very considerable, varying from 9 per cent. of the total suspended matter to 48·6 per cent. deposited upon the road; but the purification from polluting organic matter in solution was much less, and was sometimes a minus quantity, in other words, there was a deterioration due apparently to precisely the same water not being taken in the two places. There are practically no tributaries between the two points, 10,867–9, 10,931–4. The temperature was higher when the greater purification took place, 10,870, 10,874. The water was not examined for organisms, though there may have been some there. The river has no vegetation in that section, it is too polluted for that. The power of self-purification of a river depends upon what are called micro-organisms in it, but he does not know whether a certain quantity of impurity prevents the existence of these organisms. He believes that the putrefactive bacteria get on pretty well in any sort of liquid, 10,871–3. He wishes to explain a discrepancy between Dr. Tidy's statement and his own. Dr. Tidy stated that he examined the Irwell at Warrington; now the Irwell flows into the Mersey three miles above Warrington. The Mersey is a much less polluted river than the Irwell, 10,875–6. He made some experiments with London sewage, mixing one volume of filtered sewage with nine volumes of fresh water. After 96 hours the organic polluting matter of this mixture had only been reduced by 11·5 per cent., and after 192 hours the reduction was only 27 per cent. This bears out his conclusion that oxidation takes place very slowly in running water, 10,877–80, 11,228. He also mixed one gallon of urine with 3,077 gallons of deep chalk well water, and it was treated as the sewage was. Analyses were made from samples from time to time, beginning before oxidation had commenced. The results show that urine, when mixed even with enormous quantities of water, is, under atmospheric influences, very slowly oxidized. It would travel in a river, with a flow of one mile an hour, 264 miles before it would lose by oxidation 7 per cent. of its polluting constituents, 10,881. He confirmed these results by a further series of experiments by ascertaining the rate at which dissolved oxygen disappeared in a mixture of Grand Junction Company's water with 5 per cent. of fresh London sewage. He carefully determined the proportions of organic carbon, organic nitrogen, dissolved oxygen, and dissolved carbonic acid, and then put the mixture into well stoppered bottles, which excluded the air. The amount of dissolved oxygen and of carbonic acid was determined by opening one bottle every 24 hours. This was carried on for six days, 10,882–3. Assuming that the oxygen that had disappeared was used up in oxidizing the sewage (which, as a matter of fact, was not the case here), in the first period of 24 hours 6·8 per cent. of the sewage would be destroyed, 8·9 per cent. in addition during the next period would be destroyed, in the third period 14·3 per cent., in the fourth 5·4 per cent., in the fifth 5·8 per cent., and in the sixth 2·1 per cent. would have been destroyed, 10,884–6. The amount of oxygen which disappeared was about 15 per cent. in the first 24 hours. All the details are given at page 138 of the Sixth Report of Sir William Denison's Rivers Pollution Commission, 10,887–8, 10,929–30, 11,163–77. During these last experiments no sewage was destroyed, because if it had been so burnt up the proportion of carbonic acid

PROFESSOR EDWARD FRANKLAND—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

found in the bottles would have increased, whereas it remained exactly the same during the whole time. The sewage was only oxidized into more highly oxygenous compounds, 10,889–90, 11,163–77. Taking the Irwell experiments as a guide, it is impossible to say how far water so contaminated must flow before the sewage has become oxidized and converted into inorganic compounds. It is also the case when the sewage is mixed with large volumes of pure water, 10,891–92. The two red lines on Diagram A represent the mean between absolute high and low water on the 14th and 22nd September. They show the average of four analyses at each index point in the curves, and although the samples taken by him were not taken under the same conditions of time as those of Dr. Tidy, the lines confirm the accuracy of Dr. Tidy's table. The slight discrepancy between the red and black lines towards the end is probably owing to the much larger number of samples examined by Dr. Tidy, 10,893–7. He has no experiment in support of the conclusion that putrescible matter oxidizing in water will eventually give rise to bodies containing as large a percentage of nitrogen as carbon, 10,898. His opinion is that oxidation would probably take place more slowly in such a tidal river as the Thames than in a non-tidal river, but he has no definite observations upon the subject, nor has he any experience whether the effect of the presence of salt upon the process of oxidation when sewage is present increases or diminishes the rate of it, 10,899–901. On this question of oxidation he and Dr. Tidy are opposed as to the quickness or slowness of it, but they do not differ fundamentally upon the fact, 10,902–4, 11,212–28. He differs also from the conclusions Dr. Tidy drew as to the results obtained from the Shannon experiments, because the troughs were exposed to all kinds of dust and dirt; secondly, because, being V-shaped, the suspended matter underwent some sort of putrefaction, or at all events formed the nidus for bacterial life and organisms of that sort, which are no doubt very active in destroying sewage matter. His experience of sewage and sewage-contaminated water is that such matters purify much more rapidly by putrefaction than by oxidation. They are much more offensive and injurious while putrefying, because the gases are mixed with sulphuretted hydrogen usually during putrefaction, 10,905–15, 11,134–7, 11,212–32. Another thing occurs to him, that probably the diminution in the organic matter which Dr. Tidy found upon that occasion was due to the decomposition of urea in the fermenting matter which was deposited in the V-shaped gutters, 10,916–20, 11,212–32. It is very probable that in a river where sewage is mixed with large quantities of river water there is a great development of living organisms which play a very important part in dealing with sewage elements, although he is not personally familiar with the subject. He has made observations in the unpolluted portions of the Thames, where all these things would be in activity, such as plant life, &c., 10,921–2, 11,212–32. In his chemical analyses he does not distinguish between dead and living organic matter, and he has not made microscopical examinations of the water in that part of the river which is now being considered, to determine what the facts are, 10,923–8. The decrease of organic carbon on one occasion in the Irwell from 2·134 at Manchester (Throstle-nest weir), and 1·35 at the junction with the Mersey, with an increase of ·002 of organic nitrogen (which is practically no increase), might have been caused, if there was no other possibility, by the generation of carbonic acid gas, which would cause the organic carbon to vanish to a certain extent, but as the river at the time was in a state of putrefaction, marsh gas would generate and carry off the carbon, but not the nitrogen, 10,935–41. The river Darwen, which he examined for a distance of 13 miles, showed a decrease in the quantity of organic carbon and nitrogen to the extent of 50 per cent., but this was due to the volume of the river being doubled by the reception of unpolluted water from the streams which flowed into the Darwen between the two points. He examined the Ribble, which is an unpolluted river running side by side with the Darwen, and took the composition of the water coming in as being the same as that of the Ribble, 10,942–6. He differs from Dr. Tidy in thinking that the water in the Thames above Teddington is at all times drinkable, but between Lechlade and Hampton, where the river receives the sewage of 1,000,000 people, a number of very pure tributaries flow into the Thames, including the Wey, and a considerable quantity of chalk water from the chalk springs rising up in the bed of the Thames at Reading. Then above Hampton there is a state of things very favourable to the purification of the river, namely, an enormous filtration of the river through the gravel which comes out below the next lock, and the Lambeth Water Company is drawing nearly the whole of their supply from this gravel water, 10,947–55. During flood time the Wey is purer than the Thames, but in dry weather there is not much difference between them, 10,956–7. The filtration through gravel is a very powerful purifying process, a passage through 5 ft. of gravel is worth more than a flow of 100 miles in a river. There is a true process of oxidation going on there, and even when raw sewage is used under intermittent filtration the gravel does not get blocked up or become polluted, 10,958–9, 10,965. On the principle of water finding its own level, and assisted by the weir, which dams up the water, it stands to reason that the water in the gravel beds has flowed through from the river and rises on the other side, 10,960–4. Oxidation, he thinks, is helped by the action of bacteria in the gravel, 10,966–7, 11,232. He mentions instances of gravel which has been used for five or six years for filtration of sewage not being rendered polluted, 10,968–76. Sewage in the water, even if there was no ammonia present, would be unfit to drink, and would be prejudicial to health if used for such a purpose. As it was used by ships, it may even now be so used for drinking purposes, 11,138–40. The sewage discharged into the Lea is nothing like the amount discharged into the Thames in relation to the volume of water. At the present moment he is unable to give the number of people above the intake of the East London Water Company, whose sewage is discharged into the Lea, 11,152–6. He is aware that the sewage of some of the riverside towns between London and Richmond, as well as tributaries, drains into the Thames, but he knows of no other sources of pollution in that part of the river, such as manufactories; and there is a considerable floating population. Beyond these he knows nothing of the sources of pollution, as his analyses cannot distinguish between Richmond sewage and London sewage, 11,157–62. In the experiments he made (*see* 10,882 *et seq.*), if carbonic acid was not formed, no doubt other combinations would be formed, but nothing is known of them, whether they are more or less noxious than sewage. Sewage cannot be said to be burnt until it is resolved into the products of combustion, which are carbonic acid, water, and nitrogen. These were not formed in this experiment. Combining with oxygen is not combustion exactly, for example, it could not be said that alcohol was burnt when it was converted into vinegar, 11,163–7. In experiments such as his, he would be able to distinguish, say, one-fiftieth part of the carbonic acid that would result from the absorption of the oxygen. In those experiments the weight of dissolved oxygen was ·946 in 100,000 parts of water; 16 parts by weight of oxygen would produce 22 parts by weight of carbonic acid by combining with the carbon. In the 168 hours nearly the whole of the oxygen was absorbed, and the quantity of gas boiled off in the shape of carbonic acid was very large indeed, and there was no difficulty in estimating it. Carbonic acid can be determined with very great precision, to the extent of one-tenth of one per cent. in a gaseous mixture, 11,168–74. He has no very positive evidence of the absorption of the carbonic acid by the bacterial bodies in the water. He made experiments of that kind by putting putrescent mutton broth into an atmosphere of carbonic acid, and the liquid generated bacteria, but during a fortnight he did not notice any diminution in the volume of gas, 11,178–80. In air the percentage of carbonic acid present can very simply be determined with great accuracy, and in water it can practically be eliminated without any difficulty to about one ten-thousandth part, 11,181–4. There is no fixed quantity of carbonic acid, as the standard quantity for water. It varies very much indeed, and within high limits in different waters, 11,185–7. By comparing the composition of the water at Erith with the composition of the water at Gravesend, it shows that practically no oxidation takes place between those two places in the river, 11,233–42. He is unable to say whether the amount of organic matter in the water influences the rate of oxidation from actual experiments. He has obtained the approximate rate of oxidation in the Irwell

PROFESSOR EDWARD FRANKLAND—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

and also in the Thames, the result of which he has already stated in evidence. He has found that if a water containing a small quantity of organic matter has been subjected for a long time to oxidizing influences, it is very difficult to get rid of it. That he conceives to be the condition of organic matter in sea water, which is very difficult to touch; permanganate of potash will not touch it, 11,243–4. He believes a considerable quantity of urea reaches the Thames, but he has not looked for it, because it is difficult to detect it in polluted liquid. Once mixed with a large quantity of fresh water, its destruction proceeds very slowly, as he has explained in describing his experiments of mixing urine with the West Kent Company's water (*see* Question 10,881), 11,273–4. He gives an analysis of the proportion of nitrogen to carbon which is to be found in the component parts of sewage.

| | | | | | |
|---|---|---|---|---|---|
| Guanine contains | 1 | part of nitrogen to | | ·857 | of carbon. |
| Guanidine | „ 1 | „ | „ | ·286 | „ |
| Allantöin | „ 1 | „ | „ | ·857 | „ |
| Urea | „ 1 | „ | „ | ·428 | „ |
| Uric Acid | „ 1 | „ | „ | 1·07 | „ |

He knows of no bodies other than those produced by the decomposition of urine which would give that result, 11,274–6.

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—He has compared the mud of the Thames at Teddington with that in other places, as well as taking a sample of mud from the River Mole. This contained only 2·63 per cent. of organic matter, and nearly the whole of that was of vegetable origin. The mud at Hampton, as illustrating the mud of the unpolluted Thames, contained 11·33 per cent. of organic matter, which consisted to a great extent of decaying leaves. The mud of the upper Thames was chiefly vegetable, 10,691–2. Below Teddington the river began rapidly to change for the worse, the water became muddy, and the mud became richer in organic matter, which proved, on investigation, to be more and more impregnated with animal matter as he went down the river. Opposite Deptford Creek the mud also exhibited an enormous quantity of red, or blood, worms, which used to be very abundant about Hungerford Bridge, 10,693–4, 11,265–72. They are also to be found in the mud off Blackwall Point, where also offensive gases began to rise to the surface, the discharge from which increased as he approached the two outfalls, 10,695. In 1879 the effect of sewage was traceable down to Erith, where the mud exhibited decided evidence of animal matter in it. He did not go below Erith, 10,700–1. Owing partly to the increased population of London and the consequent larger amount of sewage discharged into the river, and partly to the accumulation of mud banks, even as far up as Westminster, he is of opinion that the river is rapidly getting worse. In warm weather the mud banks putrefy and create a permanent nuisance. Even if the amount of sewage is decreased, the river will not improve as the mud banks continue to accumulate, 10,835–40. He hands in a "Report on the suspended "matter in London Sewage," written by himself. (*See* Appendix A. H.) It is a very elaborate investigation into the amount of suspended matter discharged into the Thames from the London sewers in 1878 and 1879. The rainfall upon every day is given, and the volume of sewage, the percentages of suspended matter, and the total amounts of suspended matter discharged on each day during those two years are also given. A summary at the end shows the aggregate quantity of mud discharged into the Thames during these two years, which gives—

For the year 1878, 505,257·5 tons of dry mud.
„ „ 1879, 541,965·8 „ „
„ „ 1878, 1,263,143·65 tons of wet mud.
„ „ 1879, 1,354,914·38 „ „

The wet mud is taken as containing an average of 60 per cent. of water as it was dredged up. The water was run off and the mud weighed, and then dried. It is supposed to be dry at the temperature of boiling water, 10,844–51, 11,020–37. The reason for making this enquiry was that little or no notice had hitherto been taken of the discharge of suspended matter during

PROFESSOR EDWARD FRANKLAND—*continued.*

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS—*continued.*

storms, but only in fair weather; and he wished to ascertain what effect storms would have in increasing this quantity, 10,848, 11,020–37. During storms the proportion of mineral matter brought down is very much increased, but the mud is much less polluting than in fair weather, 10,852–8, 11,020–37. He struck out of his table (section 2) the two first observations, because they were abnormally low, below the fair weather average, in fact; had he left them in, and taken the averages, the final results as regards the quantity of mud annually discharged into the Thames would not have been very different, 11,023–32, 11,188–206, 11,245–50. After a rainfall the matter collected in the sewers during a long period of drought is carried out, but the flow will continue for a couple of days or even a week, 11,033–37, 11,063–83. He has struck out other observations which appeared to him to be of no practical use in giving reliable results, because the rainfall was so slight, but the facts given are trustworthy, 11,043–54, 11,188–206, 11,245–50. He does not believe that the system of catch-pits introduced into the sewers to prevent the road matter getting into the sewers in any quantity are efficient, as they only collect a very small portion of the mud. He has made numerous observations in London and in many towns in the provinces which confirm his opinion, 11,038–42, 11,253–6. The paucity of observations in section 4 is due to the fact, that the chemist of the Metropolitan Board of Works suspended taking his samples during a heavy rainfall, 11,055–62, 11,257–61. Table C. gives the working out and the application of the averages for 1878 and 1879, and on the day 2½ inches of rain fell the total number of gallons of sewage, plus the rain and water supply, was equal to 3,676,000,000 gallons, allowing 20 per cent. for evaporation, and as this amount is seven times the capacity of the amount that goes through the main outfalls daily, he presumes it escaped by the storm outlets, 11,084–92, 11,207–11, 11,262–4. He quotes some extracts from Sir J. (then Mr.) Bazalgette's Report to the Metropolitan Commissioners in 1853 in support of this statement, 11,262–4. The red worms he believes follow the sewage, which would account for their disappearance from Hungerford Bridge, 11,265–72.

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER.—He has used Professor Way's table to ascertain the proportion of sea water at various places on the river by means of the chlorine test, 10,797–9. The presence of sea water (in connection with the float experiments) affords evidence of sewage pollution at points far above the main outfalls, because it is obvious that the sea water cannot get past the outfalls without taking the sewage with it, 10,800. His analyses of sea water differ slightly from the results obtained by Dr. Tidy. Along the coasts it is always a little more dilute than in the middle of the Atlantic. The average quantity of chlorine he makes out is 1,975·6 parts in 100,000. He gives the quantity found in samples taken at different places on the coast, about one mile from the shore, and one foot below the surface. He thinks it very likely that the chlorine in sea water away from the shore always bears a definite relation to the total solid matter in the water, but he has not been able to verify it, 10,801–10. The average quantity of chlorine in London sewage is 10·3 parts in 100,000, in Thames water it is ·2, 10,811–12. The proportion of chlorine in all parts of the cross-section of the river is substantially the same (as shown by Professor Way's analysis), and the importance of establishing this fact enables him (and others) with much confidence to calculate the proportion of sea water in the river; at different depths and at different positions it is the same. The mixture takes place partly by eddies and partly by diffusion. It is not due to any chemical affinity, but to mere mechanical diffusion, 10,813–16. The tables he has put in show how enormous is the influence of the floods during their continuance in pushing back the sea water. At North Woolwich, for instance, during high water in September, one-third of the river was sea water, while on the 30th November at high water only one-fifteenth of the river was sea water, 10,817–19. He has determined the proportion per cent. of sea water at various points in the river from a number of samples collected on the 30th November, with the following result:—

PROFESSOR EDWARD FRANKLAND—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

| Place. | High Water. | Low Water. | Remarks. |
|---|---|---|---|
| Teddington - | Nil | Nil | There was a very heavy flood in the river at this time. |
| Chiswick - | Inappreciable | Inappreciable | |
| St. Paul's Pier - | do. | do. | |
| Deptford - - | ·95 | do. | |
| North Woolwich | 6·6 | do. | |
| Barking - - | 8· | ·17 | |
| Crossness - - | 15·3 | 8·7 | |
| Erith - - | 17· | 4·3 | |
| Southend - | 90·8 | 78·1 | |

These deductions are partly from his own analyses and partly from those of Professor Way, but the two sets of analyses agree very closely, so that there is substantially no difference between them, 10,820–30. During a heavy flood the sewage would be carried bodily down the river, but when it is discharged at or near low water, and when the flow of the river is normal, it reaches London, and under favourable circumstances it would get up as far as Chiswick, and to Chelsea under normal circumstances. It would then oscillate through London for many days, or even weeks, before it was finally carried out to sea, 10,831–34, 11,095.

## MR. JOHN THOMAS WAY, F.C.S., F.I.C.

Formerly Consulting Chemist to the Royal Agricultural Society.

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER.—Was a member of Lord Essex's Commission on Sewage, which sat for eight years, from 1857 to 1865, and also acted on the First Royal Commission on Rivers Pollution. He has had a very lengthened experience in relation to water supply and sewage, 11,280–5. He hands in a series of tables giving the results of his analyses of the samples of Thames water for the determination of chlorine. A resumé of these tables was handed in by Mr. Baldwin Latham, but it contained only a small portion of his experiments, 11,286–8. The tables comprise, first, the quantity of chlorine in 100,000 parts at high and low-water on the 14th and 22nd September 1882 at Teddington, Chiswick, St. Paul's Pier, Deptford, North Woolwich, Barking, Crossness, Erith, Gravesend, and Southend, the samples having been taken one foot from the surface and 20 feet from the surface. Secondly, the amount of chlorine at the same places between the 28th October and 11th November at 10 a.m. and 4 p.m., and at half tides. Thirdly, the amount of chlorine in sea water at Margate between the 29th October and 12th November, and also on the 30th November, and at the Nore between 24th September and 12th October 1882. Fourthly, the amount of chlorine in the water during the float experiments commencing 29th October, and continued daily till 7th November 1882 at flood and ebb tide. Fifthly, the amount of chlorine in various wells at Grays and Erith, 11,288. None of the samples were taken by him, but as it is important that the method of taking them should be given, he wishes to explain the process, 11,289–93. The object of taking the samples was to ascertain how far, and under what circumstances, the sea water, as indicated by the chlorine, went up the river. At the 10 places selected, in some cases three samples, and in others five samples, were collected at certain equal distances across the river, the object being to ascertain whether there was any difference in the flow of the tidal water. They were taken at one foot below the surface, in some cases as near the bottom as possible, and in other cases at 20 feet deep, whenever there was that depth of water in the river. Samples were also taken at high and low-tide. The letter A always begins on the south shore of the river, and a separate analysis was made for each sample, 11,294–301. The second table, called "Resumé," is the result of the averages of these others. The tables numbered 1, 2, 3, and 4, relate to analyses of water for chlorine which were or have been used in this inquiry, 11,302–6. There are two methods of analysis for chlorine, one the old or gravimetric method, in which the chlorine is collected as chloride of silver and weighed, the other by the volumetric method, in which the chlorine is determined by volume by means of a colour test. This being the simplest method, he adopted it for the purpose of his analyses. He has taken every step to satisfy himself of the accuracy of his results, but it is difficult, where there are large quantities of salt in the waters, to determine the amount of chlorine

MR. J. T. WAY—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

within one or two per cent. of the whole, 11,307–11. The determinations show the quantity of chlorine in the cross-section taken across the river, and it varies very little either across the river or by reason of depth. This is an important point. There is very little difference in the samples as taken across the river, or as taken at one foot from the surface, or taken deep. The resumé, which is deduced from the tables, and shows the mean of the experiments on Table I., may fairly be taken as proving the state of the river, 11,312–16. The observations of the 30th November were taken at one point only upon the river instead of across, but they were taken shallow and deep. It was found that there was no necessity to take them across, as the differences were so much less than the differences at the other stations, that it was not worth while to take them in so many places, 11,317–19. Urea decomposes in sewage at a very rapid rate, and can never be found in London sewage after it leaves the sewers. It becomes carbonate of ammonia. Urea is one of the most easily changed matters imaginable. As soon as any organic matter passes into it, it is changed almost immediately, 11,320–4. In his opinion three to five per cent. of sewage in the water would make it foul. This opinion is founded on definite observations, extending over a period of 40 years. He has in his laboratory a mixture containing 10 per cent. of sewage, but it is a very offensive mixture, 12,210–16. Of the sewage discharged into the Thames the liquid portion is not the most important part to consider. Sewage may be divided into three parts, the liquid portion, the heavy portion, which comes from the detritus of the streets, and the light flocculent part, which in great measure comes from the indigestible portion of the fæces, 12,217–19. Of this last part perhaps 10 per cent. is soluble, and the rest is insoluble in water. Its composition and character are, of course, well known, but, as part is swept away with the liquid, and part subsides, what becomes of it in a tidal river like the Thames cannot be known, 12220–1. He prefers to take sewage as if it were nothing but fæces and urine, though of course other things get in, but only in a small proportion. He calculates that the solid fæces with its water amounts to 1,750 grains per head of the population. Of this, one-fourth part, or one ounce, is dry matter. Roughly speaking, taking the population at 4,000,000 people, it gives 110 tons of dry fæces per day for the whole population of London, and, taking the moist and the dry together, it would amount to 400 tons daily, after deducting 40 tons for the soluble matter, 12,222–38. This result is very much the same as that arrived at by Mr. Lawes and Dr. Gilbert, who attempted to determine the quantity of sewage of a town by reference to the food, and what became of it. Another method is to take simply the solid and liquid excrement, and make a fair guess at it, and then calculate from it. This is what he has done. A third method is to determine by actual experiment, 12,239–40. He corrects an error of printing in the resumé of the chlorine experiments. At Deptford the chlorine at low-water should be 49·0 instead of 4·9, 12,252. He wishes to point out that, as the experiments upon chlorine were mainly intended to see where sea water and where river water was in the river, it was absolutely necessary that they should be correct, the question of the influence of the chlorine in sewage upon the quantity should be taken into account. This he has not taken into account for the following reason. The chlorine in the river water is 1·7 in 100,000 parts; the proportion of chlorine in the sewage is certainly not more than 20 (Dr. Frankland and Dr. Tidy put it down at 10, but he thinks it is higher than 10); and the chlorine in sea water is nearly 2,000. If an equal mixture of sewage and sea water be taken, say, 100,000 parts of sewage, containing, say, 20 parts of chlorine, and 100,000 parts of sea water, you would have in the one case 20 and in the other 2,000. The half of that, that is in 100,000 parts, there would be 10 from the sewage, and 1,990 from the sea water, so it makes no kind of difference, and the proportion of chlorine in the river water is practical evidence of sea water at that point. The difference between the 10 and the 20 as compared with the proportion in sea water would be very little more than the error of analysis, 12,253–5. He hands in a table showing some analyses of water taken on the 14th and 22nd September at the same places between Teddington and Southend, determined by Professor Wanklyn's method

Mr. J. T. WAY—*continued.*

Distribution of the Sewage in the River by the various Motions of the Water—*continued.*

of analysis. The samples were taken at high and low water, in some cases deep and in others shallow, and they show the quantity of free ammonia and albuminoid ammonia in parts per million, 12,264–6. The albuminoid ammonia at Teddington is a fair average of what it should be before the water is filtered by the water companies. The amount increases in quantity until at North Woolwich it reaches at high-water 1·04 parts in 1,000,000. That sample stank immensely. It was probably due to the flow of the river carrying the sewage up. There is then a gradual rise to Crossness, when it begins to decrease until Southend is reached. This shows that in the central section of the river from North Woolwich to Erith there is more sewage than anywhere else. The reason it falls off there is that the quantity of sewage in proportion to sea water is so much less, 12,267–74. The reduction of sewage by oxidation at North Woolwich would be considerable; but it is well known in chemistry that non-nitrogenous matters like sugar and gum, and things of that kind, take their own weight of oxygen to consume them; and that nitrogenous matters like gelatine, albumen, creatine, and so on, require double their weight of oxygen to destroy them; if, therefore, the sewage discharged in one day (400 tons of total fæces) were destroyed by oxygen taken from the air, the air in that neighbourhood would become absolutely without oxygen. The dry matter would be, at the lowest, 100 tons; the solid matter from the liquid sewage would be 150 tons, but the residue of the urine so far as it consists of urea would not require oxygen, being converted into carbonate of ammonia, which would leave more than half. But taking the fæces alone and oxidising it would deprive the air of oxygen, 12,275–89. The reduction of oxygen in the water (referred to by Professors Heaton and Tuson and Dr. Tidy) shows that the enormous quantity of organic material in the sewage is being oxidised, and it also shows a disposition in the sewage to be oxidised, 12,290–1. He thinks the light flocculent organic matter, when it is discharged into the river, moves up and down with the tides, depositing its heavier portions. It gradually meets with the actual mud or clay at the bottom, which has a strong tendency to combine with it. (Aluminous matters have a tendency to combine with organic matters.) It then becomes heavier and sinks, especially in slacks and places where the banks are formed, and in that way a great deal of the solid matter fails to go with the liquid matter; so that, in fact, it must be accumulating at the bottom of the river. If mud that has been collected from the bottom of the river be shaken up, it settles very much faster than ordinary sewage. He has seen large deposits of this organic mud at the bottom of the river, 12,241–3. This mud is a more serious source of nuisance than the soluble part of the sewage, because the soluble part is sooner or later taken away with the water of the river, and he would not be at all surprised to find that a very large proportion of this fæcal matter is collecting at the bottom of the river in different places. Supposing it to be collected, it undergoes fermentation there, and produces gases which are some of the most noxious and objectionable; the nastiest gases of any organic matter; and when that mud is stirred it comes up, and gives off that gas. It goes down again and produces more, and it must go on doing that until it is entirely destroyed in whatever time that may take up. But the liquid matter of sewage is already in a state very far advanced in oxidation, and is on the point of passing into other materials which are not objectionable gases. It smells very nastily at first, but the oxidation undoubtedly destroys it, 12,244. The mud in the Thames becomes much more offensive when it is stirred up, or when the gases escape by themselves. They escape more readily in the four or five warm months in the year. The black mud can positively be seen coming up to the top of the river and the bubbles exploding; so also in stagnant pools the same thing can be seen, 12,245–6. In a report he wrote to the Royal Agricultural Society in 1854 he stated that the solid organic material was more productive of injury than the liquid, and he has seen no cause to change his opinion. It is perfectly well known that the deposits upon the banks of the river are the cause of the stench, which is not so bad when the river is full. Although there may be no smell at the present time from the river, when the warm weather came, and brought the mud to the surface, the nuisance would then arise; and, in his opinion, should

Mr. J. T. WAY—*continued.*

Distribution of the Sewage in the River by the various Motions of the Water—*continued.*

it go on accumulating, the condition of the river will become a very serious matter, 12,247–51. He now hands in a table of the analyses of various samples of water taken between Teddington and Southend, showing the solid residues in parts per 100,000. The samples were taken on the 14th and 22nd September at high and low-water for the chlorine experiments on the surface and in deep water respectively. They show the solid residues in the filtered water, and are matters in solution only, which become solid by evaporation, 12,256–63.

## Mr. CHARLES WILLIAM HEATON, F.I.C., F.C.S.

Lecturer on Chemistry at the Charing Cross Hospital and Examiner in Chemistry to the Royal College of Physicians.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He lives in the parish of Erith, a mile and a half from the river. He has known the river for 20 years, and during the last 6 years has been in the habit of sailing on it, 11,325–33. In hot weather he has observed disagreeable smells coming from the river, and more particularly from the mud, frequently. When near the outfalls in cold weather, and at a distance of a mile, he has detected smells on the river. In very hot weather he has smelt the water miles away from the outfall. It has come down upon the wind. The smell last summer was slight on account of the wet and cold weather, 11,334–49. In conjunction with Professor Tuson, who also lives near Erith, he has made a series of experiments upon the composition of the water from which some important points are proved. The samples they took personally, and tested them principally for the determination of albuminoid ammonia and dissolved oxygen. They also made a certain number of determinations of nitrates on special occasions, 11,350–9. The experiments were commenced in July 1882, and were made at intervals through the greater part of the remainder of the year. He hands in a table giving a list of the places (39 in number) where the samples were taken, the date, and the quantity of free ammonia, of oxygen absorbed, and of albuminoid ammonia, in 100,000 parts of water respectively. As regards ammonia, the figures are very irregular, and he does not profess to found much upon them; but they tend to show that the river is polluted, and polluted with sewage, but to the extent of that pollution he does not pretend to speak, 11,360–2. The albuminoid process gives evidence with regard to the organic matter capable of putrefaction that is present in the water. The bad smells are due to the putrefaction of nitrogenous matter, and for that purpose it was desirable to ascertain some measure of the quantity of the albuminoid matter. The organic nitrogen determination is of the greatest value, but it is to a certain extent reduced in value by the fact that sea water contains much organic nitrogen. It is well known that the albuminoid ammonia estimation only represents some fraction of the nitrogenous putrefiable organic matter, and it is agreed that in a river like the Thames albuminoid ammonia does come from nitrogenous organic matter of some kind, capable of putrefaction, 11,363–6, 11,427–9. Unfiltered water was used in the experiments so that they should represent, as far as they were able to do so, the actual condition of the river, 11,367–8, 11,480–5. In the first place they got very considerable quantities of albuminoid ammonia throughout the area examined, viz., from Woolwich to Greenhithe; at all times of the tide, and, except at high water, when there is distinctly less, the mean results of the determinations in this way do not indicate any material difference in the composition of the water. The water was examined at high water, low water, flood and ebb, and the least proportion was found at high water, but the quantities found upon either side of the top of the tide varied very much indeed, which is due to a very great extent to the use of unfiltered water, 11,369–73, 11,480–5. He used the permanganate process for the determination of the albuminoid ammonia matter, first distilling with sodium carbonate until the liquid was quite free from ammonia, 11,374. Samples 41 and 42 have been accidentally filtered, and so they are excluded from the average. Two other samples, one taken very near the outfall and the other taken in the wake of a very large steamer, have also been excluded, 11,375–8, 11,480–5. The average amount of

Mr. C. W. HEATON—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

albuminoid ammonia in the sewage area during all times of the tide, and excluding Nos. 30, 41, and 42, is ·0937 parts in 100,000 parts, which is seven times the quantity obtained in Sea Reach. The method by which the albuminoid ammonia is obtained, is known as Wanklyn's process, 11,379–84. The quantity obtained is certainly less than what was in the water, because, when nitrogenous matter is distilled with alkaline permanganate, the nitrogen is partly converted into ammonia, but not all of it, and there is no formula by which they could multiply the albuminoid ammonia in order to obtain the quantity of organic matter. The way in which he obtained the quantity was by assuming Professor Wanklyn's estimate that you get two-thirds of the nitrogen as albuminoid ammonia to be correct. Then (and it is a mere supposition), it would give ·7 parts by weight of nitrogenous organic matter, estimated as equal to albumen, per 100,000 of water. He believes, in common with others, that the actual quantity of matter would be greater, as he does not think there is so large a proportion as two-thirds of nitrogen in the form of albuminoid ammonia, 11,385–90, 11,440. He has determined the quantity of nitrogen present as nitrates and nitrites in only a few cases. In Sea Reach at high water the quantity of nitrogen as nitrates and nitrites both together is ·1502 parts in 100,000, and at low water ·0760. On another day at Erith at high water it was ·1190. He made a second series of experiments, in one of which samples were taken at high water, at two hours ebb, and at five hours ebb upon the same spot. The quantities were at high water ·0975, at two hours ebb ·0580, and at five hours ebb ·0270, showing a reduction in the quantity of nitrates which is a matter of importance. At Charing Cross the quantity was ·2436 at low water. These experiments seem to him to illustrate the reduction of nitrates by organic matter which has been very ably and fully treated by Dr. Angus Smith in his last Report on the Rivers Pollution Commission; and also in a work published recently by that gentleman on the reduction of nitrates by excessive sewage matter, it is shown that the nitrogen is given off ultimately as nitrogen gas. He agrees with Dr. Smith that an excess of sewage has the effect of reducing the nitrates, 11,391–7, 11,475–9*a*. The quantity of oxidised nitrogen in Sea Reach was ·1502 parts in 100,000 at high water, 11,398. In making experiments upon dissolved oxygen, he adopted the Schützenberger process. The analyses were made in the boat, because it was found that the water absorbed oxygen so quickly if the sample was taken ashore, and there was more oxygen when tested ashore, than when tested in the boat. He describes the process of filling the bottle, and the result of the experiment in the boat gave ·10 cubic inch of oxygen per gallon, whereas in the short time which elapsed between taking a similar sample ashore and testing it, the amount was found to be ·14, though the bottle was stoppered and had a thick layer of paraffin oil at the top. After letting a similar sample stand four days, and then repeating the experiment, it contained ·38, which is nearly as high as the quantities found by Dr. Tidy. He presumes there must have been a diffusion of oxygen. This happened in every case. The experiments were made in October when the weather was cold and wet, which is more favourable to the water than in rough weather, 11,399–413, 11,423–6, 11,468–75. He hands in a table showing the amount of oxygen found in some samples of water taken at Erith on five days in October 1882. The amount is given in parts per 100,000, and also in cubic inches per gallon. The average, excluding one sample which is unusually high, is ·09 parts in 100,000, or ·18 of a cubic inch in a gallon. The quantity was so small as to be practically nil, and it shows that the impurities in the water keep the dissolved oxygen very low in spite of its rapid absorption from the air. He has no experiments taken in the summer time, but he thinks that the quantity in the summer would not be greater than the smallest quantity in October, viz., ·05 parts per 100,000 or ·10 of a cubic inch per gallon, 11,414–21, 11,443–53. He has not formed an opinion as to the amount of oxygen that is required for the respiration of fishes, but the results obtained in his experiments would, he thinks, be absolutely insufficient, that in fact it would be impossible for them to breathe with that small quantity of oxygen, 11,422, 11,454–5. In the Erith District, his figures as to free oxygen are rather lower than Dr. Tidy's, but in the other districts they agree pretty closely. The apparent

Mr. C. W. HEATON—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

difference is due to the determinations being made in a boat upon the spot, and not being made on shore, 11,423–6. With regard to the quantity of albuminoid ammonia he found, in flood tide, quantities that were frequently as great as in the ebb tide when the sewage was coming down. The inference he draws from that is, that the quantity of oxygen in the water being kept constantly very low by the sewage, there is not time in the course of a single tide for the destruction of these nitrogenous matters, and also that these matters appear to undergo putrefaction first and oxidation afterwards, 11,427–9. In Dr. Angus Smith's Report, pages 45 and 46, are recorded the results of some experiments upon the artificial æration with the remark that "the albu- "minoid ammonia is not much changed in any of the "ærated specimens." This is exactly what he (Professor Heaton) found, working in a different way upon the Thames. Dr. Smith also attributes the slow disappearance of the albuminoid ammonia in his experiments to the absence of putrefaction; the numbers are 10·6, 10·4, and 10·2, 11,429. In warm weather putrefaction takes place tolerably fast, and it is accompanied by a great smell, with a disintegration and destruction of the sewage. In cold weather it goes on much more slowly, so that there is a better chance for the oxygen to destroy it. When the putrefaction of a large quantity of matter is going on, and the oxygen is being rapidly absorbed, there is a smell, but when the putrefaction is very slow there would be no smell. You may have fæcal matter in the water unoxidized, but not smelling much; it is only when putrefaction with insufficient oxidation takes place, that there is a smell, 11,430–3. He cannot with any confidence express an opinion whether the injurious effects of sewage are in proportion to the noxious smell, or whether sewage is injurious or not, 11,434–6. In cold weather the sewage remains some time in the water without changing its character, 11,437–9. On the assumption that there would be ·70 of a part of nitrogenous organic matter in 100,000 parts, (*See Q.Q.* 11,385 *et seq.*) he has calculated that,—supposing the nitrogen is given off as gas, and that the carbon is converted into carbonic acid gas,—it would require 1¼ parts by weight of oxygen in 100,000 parts to destroy the albuminoids only, taking no account of other matter in the water which also requires oxygen, 11,440. The low quantity of oxygen in the water at Erith, and the rapid absorption from the air shows that the oxygen is absorbed by the sewage bodies. So much putrescible matter is found in a flood tide that it is plain the oxygen does not destroy the whole or even any large portion of it in the Thames. Certain matters are not eaten up; the nitrogenous matters are tougher, and resist the action of the oxygen, 11,443–50. The nitrogenous matter putrefies more rapidly than the non-nitrogenous matter, but it does not oxidize to any extent until it is putrefied, The cold arrests putrefaction, and so indirectly the oxidation, and there is also a very large quantity of oxygen required. Between Woolwich and Greenhithe the water is polluted at all times of the tide with nitrogenous organic matter, and there is very little oxygen, not nearly sufficient to oxidize what is there, 11,451–3. As regards free ammonia, very little will be deduced from his experiments, except that there is general sewage pollution, because free ammonia does not bring out results which are useful, 11,483–5. Much difference does not exist between the samples, Nos. 41 and 42, taken at the Corinthian Yacht Club, at Erith, and that at Kingston; but it should be borne in mind that the Erith samples were filtered, and the Kingston sample was not filtered. This latter sample was struck out of the table because no evidence was forthcoming as to who took it, or how it was taken, 11,486–90. He had no means of determining the quantity of suspended matter at varying depths in the river, and his analyses do not discriminate between the organic matter alive or dead. He does not think that if there were a great number of microscopic animals or microscopic vegetables, algæ or confervoids, he would have had the same means of ascertaining the amount of albuminoid ammonia by analysis as he would by chemistry, because it is known, as a matter of fact, that certain sewage matters which are thrown into the river (the common sewage of the river) yield a large quantity of albuminoid ammonia. He admits the weaknesses of the method in many particulars, but it is generally agreed amongst chemists that the albuminoid ammonia in a sewage

Mr. C. W. HEATON—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

polluted river does come from the sewage, 11,491–4. The sea-water contains much animal nitrogenous matter living and dead; the sample taken at night was when the water was covered with phosphorescence. Now that water, although it contains much nitrogen, does not yield albuminoid ammonia, and he thinks he can in this way, so far as chemistry is concerned, discriminate between organic, animal, and vegetable matter which is dead in the water, and animal and vegetable matter which has come out of the sewage. Unless he knew the history of the water from which a sample was taken he could only say that it was polluted by nitrogenous organic matter, but whether it was sewage, or fæcal, or from some other cause, he could not tell. Knowing sewage to be in the Thames, he has attributed it to that cause, 11,495–510. The noxious trades which are conducted on both sides of the river are very disagreeable. He has had to complain constantly of the vapours which arise from the manufactories and they exist at the present time, 11,511–14. Certain documents relating to the drainage of Erith, and to the Erith Local Board were handed in by Mr. Michael and Mr. Morice (*see* Appendix A. J.).

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—He took some samples of mud at Erith, and kept them in his laboratory for some time. In a few days it smelt most offensively, and was full of large red worms, which he had not noticed before, and were certainly not in the mud when they took the sample. He presumes they were hatched, but he does not suggest that the mud contained sewage because of the presence of the worms, 11,456–67.

## PROFESSOR RICHARD V. TUSON, F.I.C.

Professor of Chemistry in the Royal Veterinary College, and Associate of the Society of Medical Officers of Health.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He has been resident at Erith for 11 years, and has known the river for 22 or 23 years, having been constantly yachting all the time. He has frequently been on the river at night, and at all times of the day, 11,519–23. In conjunction with Professor Heaton, he made all the experiments which have been mentioned in Mr. Heaton's evidence, and, as far as scientific matters are concerned, he concurs in all he said in reply to the questions put in cross-examination, and has nothing to add to his evidence, 11,515–8, 11,540.

He considers himself fully qualified from personal knowledge to judge of the general condition and appearance of the river, which is steadily getting worse from year to year from Woolwich Pier to Greenhithe, setting aside exceptional seasons, 11,524–6, 11,553–4. For the last 10 years, judging from the blackness of the river, the stench arising from it, and its turbidity, it has been getting worse within those limits. In the middle of Long Reach it is turbid, black, and sewage-like, with innumerable bubbles sluggishly rising and discharging gas, and in hot weather this is accompanied by a most fearful stench. He does not notice it so much in the early part of the year, as he is not often on the river at that time, 11,527–33. A blackish kind of mud, followed very often by a vegetable growth, collects on the bottoms of the boats, which, when scraped off, emits a very bad smell, like decomposing fæcal matter, 11,534–37. When first he went to live at Erith, bathing used to take place nearly every day at the end of the pier, but now no bathing goes on, except amongst the "mud-larks." At low water in hot weather the stench at the Corinthian Yacht Club is exceedingly bad, 11,538–9. He looks upon that abundant and general evolution of gas, accompanied by black turbidity in the water as evidence of sewage, because he has seen immense volumes of sewage matter vomited from the northern outfall having exactly the same appearance. Fœtid gas is indisputable evidence of the existence of sewage in the water, 11,541–2. There is a small pipe where sewage is discharged just below Erith Pier. It is above where the bathing used to take place at high water, 11,545–6. From many years experience he is able to distinguish five bad smells, four arising from the chemical works on the banks of the river, and one from the river itself. As to their being noxious he can offer no opinion, but they are undoubtedly obnoxious

Professor RICHARD V. TUSON—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

and offensive. He cannot distinguish them all at the same time, but when the wind sets in a certain direction he can distinguish the predominating smell, 11,547–50. At the Corinthian Club House there is an eddy, so that whatever is in the stream is brought back to this particular spot, 11,551–2. The table that Professor Heaton handed in, showing the parts of oxygen absorbed, means absorbed by the permanganate test, 11,555.

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—He has never analysed the mud in the river, but only smelt it; and, in his opinion, the mud at Erith has increased, especially by the causeway, 11,543–4.

## Mr. LIONEL S. BEALE, M.B., F.R.C.P., F.R.S.

Professor of Principles and Practice of Medicine at King's College.

Fellow of the Royal Microscopical Society.

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—He received from Dr. Collingridge 25 samples of mud collected from different banks between Gravesend and Chelsea for the purpose of examining them under the microscope, 11,558–61, 11,620, 11,679. He found a practical difficulty in getting a sufficiently thin layer of mud between the glass slides to enable him to see the more important structures, but by taking a piece of mud about as big as a pea, and mixing it with an equal quantity of glycerine, he was able then to examine small portions from different parts of the mass, taking care to separate the coarser particles of sand, so as to get a sufficiently thin layer. This mode is fairly satisfactory, and by it the specimens can be preserved for almost any length of time without their undergoing any change, 11,563–70. He paid more attention to the organic than to the inorganic constituents, and he paid little attention to the particular kind of sand, 11,571. The microscope only roughly gives information as to quantities, and it is only by noticing the number of particles in one field, and then shifting the specimen onwards, and comparing, say, 20 fields, to see whether you meet with one, two, or specimens of the same substance, that you can roughly get the absolute quantities, 11,572–4. He has identified in the mud human excrement itself, portions of muscle, vegetable fibre, starch granules, yellow elastic tissue, and various forms of vegetable tissue, 11,575–6. Yellow elastic tissue is very indigestible, and is not dissolved by the juices of the intestines of the stomach. One form of the yellow elastic tissue comes from the ligament of the neck of a sheep, another comes from the large arteries of the body. Portions of these must almost of necessity adhere to the meat, and he can, he thinks, with tolerable certainty, distinguish between the yellow elastic tissue from the ligament of the neck and that from the ligament of the artery. These matters are constituents of human food, and having passed through the alimentary canal and the sewers, are found in the mud. Their character is so well marked that there is no doubt about them, 11,577–80. Many different forms of vegetable tissue are found, but notably common cabbage. In many cases in the mud near Crossness spiral fibres are found in exactly the same state as those which may be obtained from the fæces of a person who has made a meal of cabbage some time before. The spiral is the least soluble portion; there is nothing in the colour of the spirals indicative of their having passed through the alimentary canal, but in the tissue close to the spiral which gets stained with the yellow matter which is so characteristic of fæces. He hands in drawings illustrative of his evidence, 11,581–4, 11,696–703. These spirals are found in large numbers both at Crossness and at the other places where samples were taken. There are different forms of vegetable spiral fibre, and they resist the gastric juice, and decomposition also. The fibre dissolves and leaves the spirals. They are found in tea leaves also which he has found in the mud. He is able to tell generally where he has found each of these matters, but he has not separated the spiral vessels of different plants, 11,585–94. He has found several specimens of starch granules, some of which come from bread, wheat starch, and rice starch. He has been unable to determine the plants from which some of them came. Probably they had all passed through the alimentary canal. He has found them in the mud from Crossness, Barking, and Gravesend, and, doubtless, had he looked carefully, he could have found

MR. LIONEL S. BEALE, M.B., F.R.S.—*continued.*

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS—*continued.*

them elsewhere, 11,595–8. The muscular fibres are the undigested portions of cooked meat, principally beef, he thinks, which has been well cooked, and is not so digestible. The fibres are rendered hard and undergo very little change, probably remaining for months in the same state; they often exhibit delicate transverse markings, which are so characteristic that this tissue can be distinguished from anything else. He can trace the change it has undergone from remaining longer in the river than others; some of the fibres are granular, while those obtained from the sewage itself, or from the banks near the outfall, have a yellow colour, and are very clear and distinct, many containing transverse markings, and several retaining the same appearance which they had when passed, and which depends upon partial digestion having taken place, 11,599–604. In some cases where the markings could not be seen at first, they became visible after having been soaked in glycerine. The muscular fibre is found in many samples besides those from the outfalls, and in various stages of decay, but he cannot say whether that condition of decay depended upon the mere process of digestion or to maceration for a long time on the banks owing to the slow action of the water. He would not be able to say what proportion of the contents, say, of a pint measure, was fæcal matter, but it would be a very small portion; it would be more than $\frac{1}{1000}$th part, 11,605–12, 11,703. He could not distinguish either between the upper or lower part of a sample, but the $\frac{999}{1000}$th parts which are not fæcal matter would be principally sand, 11,613–18, 11,703. He was surprised to find so small a quantity of fæcal matter, because the smell and the appearance of the mud indicated a great deal. The samples were taken in November, December, and January. Those from Crossness smelt very badly; others had hardly any smell. Sometimes there may be a very small quantity of organic matter, but the smell may be very bad, 11,619, 11,621–3, 11,627–8. He has not examined the slimy material upon the banks, but has seen it at Erith in the summer. The samples he received, it will be remembered, were taken in the winter, 11,624–6, 11,694–5, 11,714–16. The relative proportion between the smell and the amount of organic matter varies at different times of the year, and depends upon the rate at which the offensive matter is evolved during the decomposition of the organic matter in the sewage, 11,622, 11,629–30. The yellow elastic tissue will resist decomposition for months, even when immersed in water. It is found in mud taken at Barking, Crossness, Erith, off the "Cornwall," East Greenwich, Trinity Ballast Wharf, &c., 11,631–7. The yellow fæcal masses consist partly of fæcal matter with the remains of undigested food, often with particles of sand which become mixed with them as they are moved up and down with the tide. Being viscid, sticky stuff, it would be likely to combine with the floating mud in suspension in the river. The organic constituents then gradually undergo disintegration and oxidation, 11,638–42. He finds, also, a good deal of fatty matter, speaking microscopically, that is to say; the fatty matter appears partly as oil globules, and partly as crystals, owing to decomposition. Particles of coal and soot, fibres of paper and white fibrous tissues are also found, 11,643–4. He has found products of sewage in all the 25 samples, more or less, the worst being the sample taken from an outfall just below a Trinity ballast wharf at West Ham. Near the outfalls the samples are worse than elsewhere, 11,645–8. A diatom is a low vegetable organism; it is something which is alive, but it has scales composed of silica, which resist decomposition for any conceivable length of time. He has found fragments of diatoms in every specimen of mud. They have been described by Mr. Roper in a paper which appears in the Transactions of the Royal Microscopical Society, new series, volume 2, page 567, 11,649–52. Diatoms are found in fresh water, brackish water, and seawater, and in many instances he can tell from which water the fragments have come. In some mud off the Isle of Dogs 104 species were found by Mr. Roper, 30 being marine, 29 from brackish water, and 45 being of the fresh water species; at Hammersmith 29 were fresh water species out of 43, the remainder being seawater; while at Gravesend, out of 47 specimens, only eight were peculiar to fresh water. The figures show that seawater gets up to Hammersmith, or even to Teddington, 11,653–64. They are very light, and when they die the organic part is dissolved out, leaving the silicous shells,



MR. LIONEL S. BEALE, M.B., F.R.S.—*continued.*

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS—*continued.*

fragments of which are found in the mud, 11,665–8. Bacteria are the hundred thousandth part of an inch or less in diameter, and are by no means peculiar to sewage. They are found everywhere in the air and water, and on everything; and in human beings also they exist in every tissue, in the blood, in every part of the body in health and in disease, the frame is full of them. They are alive, or their germs. If the temperature was sufficient for them to grow rapidly, and if time allowed, they would decompose the sewage and render it perfectly innocuous, but that would involve an enormous number and enormous time, and a very thin layer of the organic material spread over an enormous surface. As the sewage is discharged into the river now such a state of things is not likely to take place, and they have no practical effect on the sewage under existing circumstances, 11,669–78. He has not examined the suspended matter in the Thames, but he has examined water with mud in suspension many times, and never saw any organic beings existing in water that would be likely to destroy the suspended matter of sewage, 11,680–3. In the mud he found a large number of desmids and diatoms, and some algæ. He had no opportunity of examining the surface of the mud nor at varying depths (in this inquiry), as it was brought to him in bottles, nor did he make any quantitative examination, 11,684–7, 11,691–3. Hairs of oats were found in the mud, which, together with the spiral vessels, would probably be washed into the Thames with road detritus, 11,688–90. They are not likely to be turned yellow from other causes than from passing through the alimentary canal. The spirals found in peaty water are entirely different to those found in the Thames. These are much larger than the peaty spirals, and are mostly from the common cabbage. Straw spirals are totally different again, and these can all be identified. He would not expect to find many in road detritus, 11,696–702. In passing through the alimentary canal, spirals lose their outer envelope, but by prolonged boiling or prolonged maceration in cold water the same effect is produced, 11,704–7, 11,712–13. The yellow masses which are due to sewage have this distinctive character, that they can be broken up and squeezed between glass, and the yellow matter squeezed out, whereas the yellow matter from vegetables is usually hard and cannot be squeezed, and the yellow matter is distinct. He has frequently seen yellow matter which he should not put down as fæcal. There is no chemical reaction, but you can tell by the eye, 11,708–9. It would be quite impossible to make any mistake about the colour, even if he met with iron in the form of oxide suspended. He has compared the so called fæcal masses in sewage with actual fæcal masses, and they are exactly alike, 11,710. He could detect, without doubt or question, muscular fibre and yellow elastic tissue which has passed through the canal; the other matters, he thinks, not without some doubt, 11,711. He hands in a list of stations where the mud samples were taken from, with the dates; and he also hands in a list of diatoms found in the Thames mud, distinguishing fresh water from sea water. It is taken from a paper by Dr. Bossey, of Red Hill, and published in the proceedings of the Holmesdale Natural History Club, 11,716.

## MR. CHARLES ERNEST BRUGES.

Assistant to Mr. Baldwin Latham.

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—On the 14th and 22nd of September 1882 he went to Teddington to take samples of the water. The diagram he produces represents the positions at which he took the samples A, B, C, D, and E, and the river for that purpose was divided into six sections, 11,717–21. At each station he took samples a foot below the surface, and 20 feet below the surface, or as near to it as he could; but in no case was it taken below that depth. The bottles were cleansed chemically before he went to Teddington, and before taking the samples they were washed twice at least, sometimes more frequently In the case of the surface samples the bottles were lowered into the water with the stoppers in. They were then taken out, and replaced before the bottle was taken out of the water. In taking the deep samples, the bottles were lowered with a weight attached to them, and the neck tilted up stream to prevent any

## Mr. CHARLES ERNEST BRUGES—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

mud getting in. The stopper was then removed by means of a string, and the bottle was then drawn up, and the stopper put in before it reached the surface. In no case was any mud disturbed, and when the sample is said to have been taken at the bottom it was really taken eight or nine inches from the bottom to avoid disturbing the mud. As a matter of fact there is no mud at Teddington, it is a hard bottom, 11,721–32.

## Mr. FRANK JOB SHORT.

Assistant to Mr. Baldwin Latham.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He took certain samples of water at Deptford, but only at three stations across the river. The diagram produced represents the place where they were taken and how it was done, and it corresponds with Professor Way's description. He took the samples in the same manner, and in exactly the same way as Mr. C. E. Bruges, 11,733–9. They were taken at high water and at low water, the river being divided into four parts, 11,740–1. He found out when it was high or low water by mooring his boat to a dolphin of the pier, and then scratched marks on the piles until the water rose or lowered no more in the case of high and low water respectively. There was then a short period of slack water, and the samples were taken during that time, 11,742. In the middle of the river the samples were taken 20 feet below the surface, and at the other stations they were taken at a foot, or a foot and a half from the bottom. The bottle had a heavy weight attached to it, and was lowered quietly on to the mud; the stopper was then removed by means of a string and the sample was taken. The time occupied in taking the samples was a quarter of an hour, 11,743–51.

## PROFESSOR W. H. CORFIELD, M.D., F.R.C.P.

Professor of Hygiene at University College, and an Examiner for Sanatary Science Certificate at Cambridge.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—On the 16th October 1878, shortly after the sinking of the "Princess Alice," he examined the condition of the lower Thames, and the outfalls of the metropolitan sewers. The outfalls at Barking and Crossness were both discharging at the time of his inspection, and the sewage was flowing up steam, 11,761–6. He followed the sewage in a boat for three quarters of a mile, and it was distinctly marked by the floating material upon the surface of the water. The stench was very bad indeed at both the outfalls, 11,767–71. He took samples and specimens in several parts of the river near the outfalls, which have been deposited in the Parkes Museum of Hygiene in Margaret Street, Regent Street, 11,772–3. One sample was taken in mid-stream off South Woolwich about 12 o'clock, and another at Barking, about 100 yards above the outfall, at 5 p.m., 11,774–6. The sample collected off Woolwich was a highly polluted water, and contained ·20 parts in 100,000 parts of albuminoid ammonia, or one-tenth of the quantity in sewage. It also contained seven parts per 100,000 of suspended matter, of which 80 per cent. were fixed and 20 per cent. were volatile. The sample collected at the Barking outfall contained about 4·50 parts per 100,000 parts of saline ammonia, and 14·65 parts of suspended matter, of which 40 per cent. were fixed, and 60 per cent. were volatile, 11,777–81. These samples, when compared, give an idea of the condition of the river at the two places, 11,782. He inquired also into the circumstances of some cases of illness due to the immersion of people in the Thames at the time of the accident to the "Princess Alice." He neither saw the people nor their clothes, but he inquired of their friends and the medical men, 11,786–90. He describes in detail the particulars of the different cases, which were considered to be in some instances pneumonia, accompanied with diarrhœa, in others actual typhoid fever. In one case a medical man was of opinion that the patient was not suffering from typhoid fever, but it is a significant fact that the nurse took typhoid fever and died from it. There is no doubt these illnesses were due to immersion and the water swallowed by the people, 11,790–2.

## Professor W. H. CORFIELD—*continued.*

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—He has inspected the mud at various places in the river, but he did not take any away with him. In most places it was black and very foul, and it was for the most part very slimy, 11,783–5.

Effect upon Health in the Neighbourhood of the Main Outfalls.—For the years 1871 to 1881 inclusive, he has examined the Registrar-General's Returns to see if the state of the river produces any effect upon the health of the population upon the banks of the Lower Thames, between London Bridge and the Medway, and he has compiled some tables from those Returns, which he now hands in, 11,793–8, 11,809. Table I. contains the deaths, especially from zymotic diseases, for each quarter during the 11 years in the following districts:—Aldgate, St. Paul's, Stepney, Poplar, West Ham, Barking Town, Hornchurch, and Orsett, on the north side of the Thames. Table II. gives similar details for the districts of St. Olave, Southwark, Greenwich, Woolwich, Bexley, Dartford, Northfleet, Gravesend, and Hoo, on the south side of the Thames. Table III. shows the annual results for the districts on the north, and Table IV. for the south side of the Thames. Tables V. and VI. show the average annual number of deaths from zymotic diseases in each of the districts on the north and south respectively, 11,709–808. Tables VII. and VIII. give the average death-rate from each of the zymotic diseases, and from them altogether the death-rate per 1,000. In those tables are included London and the eastern and south-eastern registration divisions of England, in which the districts or sub-districts are. The counties, therefore, are Essex, Suffolk, and Norfolk on the north, and Surrey, Kent, Sussex, Hampshire, and Berkshire on the south, 11,809–12. Table IX. and X. show the density of the population in 1871 and 1881 on both sides of the Thames, including London and the two registration districts, 11,813–4. Table XI. shows the corresponding figures from Dagenham. This he has taken separately because he found it was included in the Romford sub-district, which includes the town of Romford as well as Barking Town and Hornchurch. Dagenham is included in that part of the sub-district which takes in Romford Town; so he obtained the figures from local sources, and gives Dagenham by itself, 11,815–17, 11,874–77, Tables XII. and XIII. give similar statistics for Rochford on the north (including the towns of Southend and Raleigh), and the two districts of Sheppey and Blean on the south, 11,817–20. Table VII shows that the average zymotic death-rate upon the north side of the Thames in six districts is either above, or very nearly approaches, what it is in London. In the first four districts it is higher than the death-rate in London; and in the last four it is decidedly higher than the death-rate in the eastern registration district with the exception of Hornchurch, 11,821–31, 11,929–32. The deaths from measles, scarlet fever, and diarrhœa, in the northern riparian districts are very largely in excess of those in the eastern registration district. He has very little doubt that one cause of the increased general zymotic death-rate along the banks of the river on both sides, and of the special increase in certain zymotic diseases, most notably scarlet fever, is the condition of the river. He has no doubt that the foul condition of the river has an effect upon the population living upon its banks. The statistics lead him to the conclusion that the high zymotic death-rate is partly due to the sewage flowing down the river, and it would be lessened if nothing but pure water flowed down the stream, 11,832–46. On the south side of the river the general zymotic death-rate is higher in all the districts than it is in the general south-eastern division. Upon the north side of the river, east of the Medway, the zymotic death-rate is a little below that of the eastern registration district; upon the south side the death-rate of Sheppey is decidedly less, and the death-rate of Blean (which is a little further on) is a little less than that of the south-eastern registration district generally. It is due to the pure sea breezes, and to the chalk, which is healthier, 11,847–52. The death-rate for measles, scarlet fever, and diarrhœa on the south is decidedly higher, with the exception of Gravesend, for measles, than the corresponding death-rate for the south-eastern registration district. He makes a further exception in the case of Hoo, where every death seems to be put down to "fever," not scarlet fever, of which there is scarcely any, 11,853–57. On the north side the deaths from zymotic diseases

PROFESSOR W. H. CORFIELD—*continued.*

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS—*continued.*

exceeds the average for London, and on the south side there is a similar excess, with the exception of St. Olave, Southwark, 11,858–60, 11,929–33. In the other cases the death-rate exceeds that of the districts of which they form a part. At Bexley the actual majority of the population is in places at a considerable distance from the river, and while the zymotic death-rate there is about equal to the death-rate of the south-eastern division generally, the death-rate from scarlet fever is very much higher than it is in the division, and very nearly approaches that of London, 11,861. The density of population in Orsett and Northfleet on the north and south sides of the river respectively is almost exactly the same as for their respective registration divisions, and the death-rate for zymotic diseases is decidedly greater in the case of Orsett, and considerably greater in the case of Northfleet, than it is in their divisions. In Northfleet it is higher than in any other place below Greenwich, 10,862–70. By taking the statistics separately for 10 years and averaging them, he has eliminated any possible irregularities in the tables which might vitiate the smaller induction, 10,871–2. He has compared the zymotic death-rates in the districts bordering upon the north side of the Thames with the zymotic death-rates of the general districts of the eastern registration division of which they form a part; then he compared the death-rate in the districts near the Thames with those in the districts lower down the Thames. He has also compared the death-rates of the places higher up the Thames with the death-rate of the districts of Rochford on the north side, and the island of Sheppey and Blean on the south side, 11,878–85. The average death-rate from zymotic diseases in Rochford for 10 years is the same as that for the eastern registration district, and is, therefore, lower than in the riparian sub-districts higher up the river. The scarlet fever death-rate is very much lower than in any of the districts up the Thames, and these healthy places in the eastern district bring down the death-rate as against the towns. Scarlet fever is a disease which is shown to be specially prevalent in those districts near to the banks of the Thames above the Medway, 11,885–94, 12,023–4, 12,035–8. He has not noticed that the registration of scarlet fever as measles in Rochford district has affected the results as shown in his tables. Such a defective registration is possible. Combining the two, the death-rate in the eastern registration division is ·57, and in Rochford alone ·44, 11,895. He has not got the details of Grays and Purfleet separately; they are included in Orsett, and the zymotic death-rate in that district is certainly higher than in the eastern division, 11,896–8. Sheppey is divided into Minster and Eastchurch, and Minster stands on high ground, 11,899–900. The zymotic death-rate in Sheppey has averaged during the last 10 years 1·90 as against 2·38 in the south-eastern registration division generally. The influence of the sewage has died out before reaching Sheppey, hence the low death-rate. The same remark applies to Blean also. Blean is a district beyond Sheppey, and includes Herne and Whitstable, 11,901–2, 10,904. In scarlet fever the rate in both these districts is less than in the south-eastern registration district, and decidedly less than in any of the districts upon the south of the Thames, with the exception of Hoo, where everything is registered as fever. The soil of Sheppey is practically all tertiary clays or post-tertiary alluvial deposits, which extends to all those districts. The chalk is not reached until you come to Canterbury, 11,903, 11,905–7. In all his tables he lays special stress upon scarlet fever as an indication of the health of the population upon the banks of the Thames, 11,908–9, 12,023–4. Apart from any other element, the density of the population has a great deal to do with the deaths from zymotic diseases, consequently the death-rate in any of the districts of London may be expected to be higher than country districts, though he could point out a number of cases of less zymotic disease with a denser population, 11,910–17, 12,017–22. The death-rate in those districts inhabited by the poorer classes, such as the East End of London, would be higher than in those parts where the better and higher classes principally reside, and as a matter of fact the population of the East End is denser and poorer than the West End. These two causes, therefore, both operate to raise the zymotic death-rate in the East End above the average, and this applies to all Eastern London, whether riverine or not (*see* Tables IX. and X.), 11,918–28. The zymotic death-rate of Barking and West Ham is very little below the death-rate of London, whereas their density is enormously less, 11,933–34. The fair way to compare the death-rates of the riparian districts is, not with the death-rate of London, but with the death-rate of the registration divisions to which they belong. St. Olave's may fairly be compared with London, Greenwich with London or the registration division. Greenwich Park lowers the rate of Greenwich by adding to the acreage without increasing the density of the population, 11,935–44. The towns in the Rochford, Sheppey, and Blaen districts are estuarian places, and the density of the population is very thin. So it is fair to compare them with the death-rates of the registration districts, 11,945–7. In Tables VII. and VIII. the population of the selected districts for the most part is near the river, although in a few cases it is situated away from it. He hands in a map on which the districts have been roughly marked out. He is unable to say how far the deleterious influence of the Thames can be conceived to extend. Although he is told that the sewage can be smelt three miles away from the river, he has never smelt it himself so far away, 11,948–9, 11,954–5. His districts begin at London Bridge, and the City is, therefore, not included in them. Stepney, which is in Limehouse, runs back about a mile from the river; Poplar extends 2½ miles back; Barking Town (which means the district and not merely the town) goes back rather less than 2½ miles; the death-rate is 3·12 as against 3·84 for London generally, and 2·38 for the eastern registration division, 11,950–3, 11,955–8. The population of West Ham is mostly away from the river, the docks intervening between it and the river. The northern outfall is included in this district, 11,959–63. Although Barking has a remarkably low average of zymotic disease, yet it has an enormously high death-rate from scarlet fever, higher than the east of London and the other places, 11,964. The report of Mr. Rawlinson in 1869 on the alleged nuisance and injury to health from the discharge of sewage at Barking, which he considered were not sufficiently established, precludes Barking from being used as a criterion to a certain extent, 11,964–8. He has included St. James's, Bermondsey, in his tables as well as St. Olave's, Southwark, St. John's, Horsleydown, and Rotherhithe, all being riparian, 11,969–70. He has no doubt that the death-rates of the floating small-pox hospital has been included in the Greenwich district zymotic death-rate. He has not eliminated them from his tables, which were taken from the quarterly returns of the Registrar General. He found it was impossible to do it. The same remark applies to St. Olave's district in which Guy's Hospital is situated, and to the other districts also. There are hospitals for zymotic diseases in several parts of London, but they are not situated specially about the river, 11,971–87, 12,014–6. Patients suffering from certain zymotic diseases, such as enteric fever and diphtheria, and in a few cases scarlet fever, are admitted to the general hospitals; but there are special fever hospitals at Homerton and Stockwell, and there is a small-pox hospital at Deptford, 11,988–93. The rate of zymotic disease in the upper part of the metropolis has fallen since the sewage has been taken lower down the river, 11,994–7. Most of the population of Woolwich is within a mile of the river, and the farthest part is about three miles from the river. The Bexley district runs back about five miles, and the Dartford district goes back to a similar distance. The farthest point in the Northfleet district is about 7½ miles from the river, 11,998–12,003. He has included in these districts, or in parts of the sub-districts which he has been able to take, nothing but what is included in the sub-district of the Registrar-General. No doubt the better plan would have been to draw a line from the river to the point where the influence of the river terminates, and ascertain what the death-rate in that portion would be; but it was impracticable, 12,004–5. Deducting the deaths from small-pox, the zymotic death-rate of Greenwich is then lower than the other districts, 12,006–7, 12,014. The high death-rate in Hoe he attributes to diarrhœa, which is caused by drinking impure water. As he explained before, he does not attach much importance to the death-rate as everything is put down to "fever." There is no other way of accounting for the fever death-rate than that,

PROFESSOR W. H. CORFIELD—*continued.*

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS—*continued.*

12,008–13. On the south side of the river the density of the population in all the districts, except St. Olave's, is less than the density in London, while the scarlet fever death-rate in Gravesend, Woolwich, and Northfleet is higher than, and Greenwich and Dartford nearly as high as, that in London, 12,017–22. He presents his tables, firstly, as facts to be considered, and, secondly, that in his opinion the emanations from the river must have some influence upon the death-rate. He thinks the sewage in the river is one of the principle causes operating upon the zymotic diseases upon both sides of the river. He has no data for eliminating other causes in forming this opinion, and can only point out that some of the districts, which have only places near the river, give examples of very high death-rates. Dagenham, for instance, which is close to the river, has a very high zymotic death-rate, and an exceedingly high scarlet fever death-rate. It is low and marshy, but that has not much to do with scarlet fever, 12,027–33. He has not had time to obtain statistics of other riverine districts where no sewage flows into the river for the purpose of comparison with the Thames, 12,034.

## MR. BENJAMIN BROWNING, L.R.C.P. Lond., S.Sc.C. Edin., F.C.S., &c.

Medical Officer of Health to the Parish of Rotherhithe, and Surgeon to a Sub-division of the M. Division of Metropolitan Police, and to a Sub-division of the Thames Police.

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—He has lived at Rotherhithe for more than seven years, and during that time has paid a good deal of attention to the condition of the Thames. He has examined the water and mud of the river at different times, and on several occasions has taken samples of the water during the past five years for the purpose of examining them chemically and microscopically for his own information, 12,039–50. The first conclusion to which he has come with regard to the effect of sewage as it is poured into the river is that a considerable portion of the sewage which is discharged into the river at Crossness and Barking is not carried down to the sea directly, but is brought up the river at least as high as Limehouse, if not higher. The second conclusion is that whilst the sewage is thus retained in the river it undergoes decomposition and becomes injurious to health; and the third conclusion is that the number of cases of various illness, such as fever, especially typhoid fever, scarlatina, various throat affections, general malaise, and sometimes diphtheria, as well as some cases of diarrhœa are directly attributable to those emanations from this decomposed sewage. He has satisfied himself of this after attending patients, and going out, in the case of the Thames Police especially, by day and by night at the same time of the tide to which they said they had been exposed to those emanations, 12,057–9. He has proved that the sewage ascends the river, by the eye, smell, and touch, and also by microscopical and chemical evidence, 12,077. In 1878 there was in Rotherhithe a stagnant piece of water known as the "mill-dam," which was in a very offensive condition. That has been piped, drained, and put in repair, and now does not exist. The numerous privies and drains, which at that time discharged into the Thames, have since been cut off, 12,171–5. He does not think they were in existence in 1881, as stated by Dr. Collingridge in his report. If they were they had been opened again, though he could not find any trace of them when he specially examined the foreshore of Rotherhithe in that year, 12,199–208. The only nuisance left is the Thames, which, he thinks, is the chief nuisance, 12,209. Most of the pollution of the river is brought up from the outfalls on the young flood. The river is more polluted then than at high-water, 12,148–50.

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—He has taken specimens of the mud near the outfalls, and as high up as Wapping, and also at the Surrey Commercial Docks. He found it black and very fœtid, and to the best of his knowledge and microscopical observation, it contained evidence of sewage, 12,078–81.

MR. BENJAMIN BROWNING—*continued.*

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS.—He has under his care 50 officers and men of the Thames Police, besides a large number of land police, and in addition he has the medical care of a number of clubs amounting to between 600 and 700 workmen in all. They are composed for the most part of waterside people, bargees, watermen, lightermen, and boatmen. Having in some cases investigated the statements of a number of people who attributed their illness to the smells from the river, he has come to the conclusion that a considerable portion of the sewage discharged at both the main outfalls is not carried down to the sea directly, but is brought up the river at least as far as Limehouse, if not higher; that whilst the sewage is thus retained in the river it undergoes decomposition, and becomes very injurious to health; and that the number of cases of various illness, such as fever, typhoid fever especially, scarlatina, various throat affections, general malaise, and sometimes diphtheria, as well as some cases of diarrhœa are directly attributable to these emanations from this decomposed sewage. He has satisfied himself of that after attending the patients and going out, especially in the case of the Thames Police, by day and night at the same time of tide to which they said they had been exposed to those emanations, 12,051–9, The members of the clubs, when ill, are entitled to sick pay, and he investigates their case. If they wish it, irrespective of his own judgment, he puts them on the sick list. With the police it is different. They are men in the prime of life, carefully selected, of good physique generally, and with good hygienic surroundings in their houses, most of which he has personally inspected, and they are less likely than others to be affected by surrounding circumstances. There is no temptation on their part to pretend to be ill, because a considerable portion of their pay is stopped when they are ill, 12,060–7. Out of 146 cases of illness in five years amongst the 50 men of the Thames Police, he has had 18 cases of various forms of illness which to the best of his judgment, and in the belief of the men themselves, were attributable to the emanations of the river to which they were exposed when on duty, between London Bridge and Greenwich, and also to Barking, 12,068–71, 12,129–42. There is much more sickness amongst them than amongst the land police, with the same conditions as to pay and hygienic surroundings. The proportion, roughly speaking, is about two to one. He does not refer to exposure to the weather. All such cases he has eliminated from his figures, 12,072–6, 12,116–23. The health of his patients varies according to the season of the year, and on comparing his riverside patients with those who work away from the river, he finds the latter do not suffer from what he terms "riverine" complaints. The nature of these complaints is a special form of sore throat, a great deal of malaise and languor, a sort of ill-defined fever, and more or less diarrhœa. He has found diphtheria distinctly attributable to it, and he has traced cases of typhoid fever to drinking Thames water from alongside ships, 12,082–6, 12,204–6. The average zymotic death-rate in Rotherhithe for the last ten years has been 3·83 per 1,000, which is higher than many other corresponding riverine districts, but below the average of London. This may be due to his removing a great many cases of fever to hospitals outside of his parish, 12,087–96. He has nothing to do with the "Royalist," but he has had men transferred from the ship to his district, who have complained of the situation, 12,098–103. Last year he had only two cases of illness in the river police which were due to the river, one of which was blood poisoning followed by an abscess. During five years he had only five cases of blood poisoning, and one of them was dyspepsia. Blood poisoning, as a rule, does affect strong healthy men, their *vis vitæ* enables them to escape in many instances, even when exposed to its influencing causes, 12,104–13, 12,124–200–203. He does not remember a single case of blood poisoning amongst the land police, 12,114–5. The term "malaise" is difficult to define, but he can best describe its meaning by the expression "all-"overishness," 12,125–6. There are not many factories in Rotherhithe, and those in Bermondsey are a long way from the river, 12,127–8. In addition to the 18 cases which he cannot positively put down as due to the river, there were about double that number of doubtful cases. He shows one case in his extracts which was due to derangement of the functions of the stomach and liver, and was attributable to the emanations from the river. As that man was under his care and treatment for the same ailment on six or seven

## Mr. BENJAMIN BROWNING—*continued.*

Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

different occasions, it ought to appear as six or seven cases instead of one. Another man suffered from the same complaint, but his case was so serious, and lasted so long, that he was discharged from the service in consequence, 12,132–4, 12,200–3. The cases of diarrhœa which occur in the summer he attributes to the river on the men's own statements, and also from his knowledge of their diet; he has not put down a single case of diarrhœa unless the man who suffered from it was, or professed to be, a total abstainer, 12,135–9. A case of gastritis he put down to the river, as the man worked in the lower part of the Thames at low tide, and complained of the smell from the mud. He also was a teetotaller, 12,140–2. Those men who work in the docks and not on the river are free from those stomach affections, although the docks are filled with the water from the river. He concludes that the same emanations do not rise from the water in the docks, 12,143–7. None of the deaths from typhoid fever occurred in the streets or district of Rotherhithe contiguous to the river, except in Rotherhithe Street, which is parallel to the river, and always has had its fair share of mortality of all sorts, 12,151–3. In 1856 Rotherhithe was supposed to be one of the most insalubrious suburban districts, being almost entirely unsewered, marshy, with a scanty water supply, and that so contaminated as to be usually refused by horses. The marsh has now been done away with, having been drained and built over gradually until the present time. The "corrected" death rate is 18·8 per 1,000 now, and so far as that is concerned, Rotherhithe is not insalubrious, 12,154–70. In 1878 a horrible and dangerous nuisance was caused by a man named Judd, who collected, to an enormous extent, fish refuse for manure making in several arches of the South-Eastern Railway. This has been put down, and the man is now in prison, 12,176–8. The "corrected" death-rate of Rotherhithe for 1881 is 18·7. He has no statistics as to the sickness rate, because so much sickness, especially zymotic sickness, is very carefully concealed, and consequently any statement he might prepare on the subject would be perfectly valueless, 12,179–82. His annual reports to the vestry do not refer to any illness being attributable to the river, because the vestry declines to go into matters which pertain to other bodies. He therefore limits himself to those causes which are under the control of the vestry, 12,183–97.

## Mr. WILLIAM HICKS,

Keeper of the Port Sanitary Authority's Hospital Ship "Rhin."

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—The hospital ship "Rhin" is anchored one mile below Gravesend, and on the 14th and 22nd September 1882 he took three samples of water each day, as nearly as possible in the same places, and under precisely the same conditions. The samples were labelled North Shore, Middle Channel, and South Shore. He took the first sample alongside of the ship about a quarter of a mile from the shore, one a foot below the surface, and one 23 feet below the surface. He then took two samples in mid-channel at high and at low-water at the same depths (mid-channel being half a mile from the shore), and he obtained two samples on the north side, a quarter of a mile from the shore. When unable to take the samples 23 feet below the surface he took it at 20 feet below, 12,292–313. He knew when it was high and low-water by the swinging of the ship at the ebb and flow of the tide. He was about 20 to 30 minutes taking the samples, roughly speaking, 12,314–25. The mode in which he took the samples was, first, he put the bottle into a bag with a weight attached, and lowered it to the required depth. He removed the stopper from the bottle by means of a line, allowed the bottle to fill, and then hauled it to the surface. On no occasion did he touch the bottom, because his ship draws 17 feet of water, 12,326–37.

## Mr. WALTER BOUND,

Pier Master at Erith.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—On the 14th September 1882 he took some samples of water from the Thames at Erith in four different places across the river at high and at low water, in a line from the pier to the Red House on the north shore. He divided the

## Mr. WALTER BOUND—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

distance across the river, as nearly as he could, into equal parts, 12,338–45. When he had collected all his samples in the boat he corked and labelled them, and then took them ashore. It took him a little more than half an hour to take the samples. He also took some more samples on the 30th November, and again on and after the 10th October, for some days; he took some samples from off the end of the pier, 12,346–55, 12,357. To obtain the deep samples he had a line fixed to a lead, and a mark to show 20 feet. He also had a line to the stopper, which he drew out when the bottle was at the proper depth and filled the bottle, 12,356. He took two samples at each place, one just below the surface, and the other at 20 feet below. He did not touch the mud on any occasion, and at low water he took the same places as at high water, 12,358–62.

## Mr. WILLIAM BRADLEY,

Lighthouse Keeper at the Pier Head, Southend.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—By direction of the Port Sanitary Authority he took samples of the Thames water at Southend on the 14th and 22nd September, and the 30th November 1882, at high and low water, 12,363–7. On the first two days he took eight samples at each tide, beginning at half a mile from the pier, and then at each successive half mile till he reached two miles; one sample he took a foot below the surface, and the other at a depth of 20 feet. He took none on the north side of the river, 12,368–72, 12,381–3. To obtain the deep samples he made the bottle fast to a lead-line, and attached a string to the stopper. He then lowered the bottle to the requisite depth, withdrew the stopper, and in two or three minutes pulled up the bottle, which he re-corked and labelled. It took him about an hour to collect the samples and bring them ashore, 12,373–80.

## Mr. CHARLES WOOD,

Superintendent of the Wreck and Mooring Service of the Thames Conservancy.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—He has been in the service of the Thames Conservancy since 1869, and during that time he has been engaged in raising wrecks in the Thames. He had 20 years' experience before that, 12,384–9, 12,432–3. In the course of that time he has found considerable difference in the condition of the wrecks, owing to the quantity of mud in the bed of the river, 12,390–91. In 1861 a vessel was sunk in Halfway Reach, and when raised she was put on the shore above Dagenham Dock about a week later. It was hard, clean shingle, and the little mud in the ship had flowed into her from settlement. Twenty years after (in November last), another vessel, after being in collision, was run ashore at the same place, and there were nine feet of mud on the shore. The surface was white, but underneath it was black mud, all sewage, 12,392–407, 14,434–8. Last month he raised two barges in Northfleet Hope, which had been in the water a week, and five days, respectively. They had a large quantity of loose white mud in them, far more than he found in 1861, 12,408–14, 12,435. There is a great deal of black mud in Northfleet Hope which smells. It is quite unlike ordinary Thames mud, and the chains for raising wrecks get smothered with it. The same sort of mud is found in Halfway Reach and Gravesend Reach, 12,415–21. In former years the bed of the river used to be clay in some parts, and gravel in others. There was none of this black mud, 12,422–4. Above Greenwich the water is brighter; there is less mud since the opening of the outfalls, but it is much worse than it used to be below Greenwich. From Woolwich to Sea Reach the water is very bad, and the worst parts are Gravesend Reach and Lower Hope, and also Jenningtree Point, where the bottom has grown up 10 feet within the last few years. Sponges, rags, and guts, &c. are found to a very great extent in the mud there. A ship could be loaded with sponges and rags at that point, 12,425–31. In former times there used to be a deposit of mud in the Upper Pool, perhaps three or four feet deep. It was totally different to the black mud which is now met with, and it has been washed away from the pool by the large quantity of land water which has come down the river of late years. It will in all probability accumulate there again, 12,439–49.

## Mr. GEORGE CUSTANCE,

Formerly Pier Master at Erith.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He was pier master at Erith for 19 years, and left in October 1881. He is now 65 years of age, and knows the condition of the river at Erith well, 12,450–5. He remembers the outfalls being opened at Barking and Crossness, and at Woolwich prior to the opening of the outfalls, the water was used for drinking purposes, and at Erith the river was clear, wholesome, and healthy, and was used for cleaning purposes. "It was beautiful water." Now the condition of the river is very bad and cannot be used for cleaning decks or scouring at half ebb, 12,456–62. There is a sewer which goes out a long distance away from the pier to about 400 feet below low-water mark, but that does not affect the state of the river. He has not noticed that this sewer is imperfect in its condition, 12,470–2. When he was in the Steam Reserve at Woolwich in 1847 he used to drink the Thames water daily, but it has long been unfit for drinking purposes, 12,478–80, 12,489–94.

Popular Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—There used to be a small reservoir at Mr. Beadle's coal wharf to wash away the mud, but since the opening of the outfalls it has been enlarged to wash away the accumulation of mud from the outfalls. There never was any tendency for the mud to deposit there, 12,481–7.

Effect upon Health in the Neighbourhood of the Main Outfalls.—He has had occasion to complain very much of the smell of the river, which gave him great headache and diarrhœa. It used also to affect the men and produce headache and stomach-ache from the vapour and smell arising from the mud. He has known people land upon the pier and turn back at once on account of the smell, 12,463–9. The smell is worst in the summer time, and he has had to knock off work for a day or two at a time on account of it, and place himself under medical treatment, 12,473–7.

## Sir JOSEPH WILLIAM BAZALGETTE, C.B.,

Engineer to the Metropolitan Board of Works.

Description of the Main Drainage Works, and Capacity of the Drainage System as compared with the Demands upon it; Influence of this on the Storm Discharges.—Before describing the works which have been carried out for the interception of the sewage from the river, he wishes to refer shortly to what has rendered these works necessary. The Thames is situated in the bottom of the London basin, which is bounded on the north by Hampstead and Highgate, and on the south, though more distant, by the Surrey hills. The rain water from the hills flows into that basin through the riverets and brooks, the leading ones on the north being the Eel Brook, the Ranelagh, the Stamford Brook, and the Brook Green sewer, the King's Scholar Pond, the Fleet, the London Bridge sewer, the Irongate sewer, and the Ratcliffe Highway sewer; on the south, the Falcon Brook, the Effra, the Duffield, the Earl, the Great St. John's, and the Ravensbourne. (This last is now converted into a sewer and is covered in.) These riverets flowed from the high ground down into the low ground, which is considerably below the level of high water, and before it was embanked the tide flowed up those streams and flooded the low lying ground. At that time (prior to 1847) it was penal to discharge any sewage into these brooks, 1–3, 36–7. Before the general introduction of water-closets, all the sewage went into cesspools, and continued to do so until the water-closet system rendered it impossible, when overflows from the cesspools into the sewers or brooks were for the first time permitted. These cesspools became so numerous that they were found to be a source of disease, and in 1847 the sewer system was introduced, and about 30,000 cesspools were destroyed. These open sewers were then covered in, and they discharged their contents into the Thames at low water, the worst period, for sanitary reasons, because the sectional area of the river at low-water is very much smaller than at high-water, and secondly, because the sewage, instead of being carried away by the ebb tide from London, was carried from low-water to high-water up the river, 3. He has prepared, and hands in, a section of the Thames at London Bridge showing the sectional area of the water at high and low-water, 3–5. Putting a "float" into the river at high-water, as compared with low-water, makes a difference of about 12

## Sir JOSEPH W. BAZALGETTE—*continued.*

Description of the Main Drainage Works, and Capacity of the Drainage System as compared with the Demands upon it; Influence of this on the Storm Discharges—*continued.*

miles, so if a float be put in the river at low-water, say at 12 miles below London Bridge, it will upon an average of tides float up to London Bridge, so the sewage having been put into the river at low-water for some years, and flowing up, caused a nuisance which led to the formation of the Metropolitan Board of Works in 1855, 5–8. Their first duty was how to overcome this difficulty, and the difficulty was very greatly increased, from the fact that whilst the sewage was of comparatively small quantity, and tolerably uniform, the rainfall was a very excessive and a very variable quantity, amounting sometimes to an inch, or even to two or three inches in an hour. As much as four inches have been known to fall in some parts of London. Now the maximum flow of the whole sewage of London does not amount to $\frac{1}{100}$th of an inch per hour in quantity over the whole area, 8–9. This question has been and still continues to be a great difficulty. To separate the rain water from the sewage would have involved the redraining of all the houses in London, at a cost of 8,000,000*l.*, and the construction of separate sewers at a still further expense, to say nothing of the very powerful resistance to such a proposal. It was therefore considered impracticable, 9, 188–93. As there are only 14 to 21 days in the year on which the rainfall exceeds a quarter of an inch in 24 hours, it was considered possible to divert from the present sewers, which discharged into the river, the whole of the sewage and a quantity equal to a quarter of an inch of rain running off with it. This was done by constructing lines of sewers at right angles (or nearly so) to this main valley sewer, which ran from the high ground down to the river, and began by intercepting it at the upper points, so as to carry the sewage as much as possible to high-water by gravitation, to save pumping. In this way the high level sewer was commenced at Highgate and Hampstead, passing through Hackney and Stratford to Barking Creek. It intercepts the sewage from an area of 10 miles, and beginning by being four feet in diameter it increases at the lower end to 9 feet 6 inches by 12 feet. Its length is 7 miles, and it has a fall of 75 feet to the mile at the upper end and 4 feet at the lower end. It takes nothing from below it, 9–11. The sizes of the intercepting sewers are graduated to take the calculated quantity of sewage and rainfall whenever they are filled; near the top of them is a long weir, over which the surplus water flows (when the rain exceeds the normal quantity) into the main sewer at a lower point, and this is the principle upon which the storm waters are allowed to pass from the intercepting sewers into the river, 11–12. The middle level sewer commences at Kensal Green, passing through Oxford Street and nearly in a direct line down to the high level sewer at Bow, where the two run parallel, but distinct, having the means of communication, if desired, to equalize the flow at the outfall. It is 4 feet 6 inches by 3 feet at the upper end, and increases to 10 feet 6 inches in diameter at the lower end. Its length is 11½ miles, with a fall from 17½ feet down to 2 feet in a mile. The low level sewer commences at the pumping station, and passes through Pimlico, along the Victoria Embankment, through the City and Stepney to the Abbey Mills pumping station. There it is lifted to the level of the two other sewers, and the three pass by parallel sewers down to the reservoir at Barking. It drains an area of about 11 square miles; it is 12½ miles long; its diameter increases from 6 feet 9 inches to 10 feet 6 inches, and its inclination varies from 3 feet to 2 feet per mile, 13–15, 12,746–65, 12,785–93. The area beyond, containing Chelsea, Hammersmith, and Acton, which is termed the "Western Division," has a separate set of sewers, which pass from Hammersmith through Chelsea to Pimlico, where the sewage is lifted in the low level sewer, 15. The whole area, both north and south, for which the Metropolitan Board of Works has to provide, contains about 117 square miles. Upon the north side 53 square miles, and on the south 66 square miles, 16–19, 92–93. On the south side the high level sewer has a main line and a high level branch, which together intercept the sewage from 20 square miles. The main sewer commences at Clapham, passing through Brixton to Deptford Creek, where it is joined by the branch line which starts at Dulwich and goes through Peckham. These pass under the Creek and have a storm outlet into the Creek. The southern

SIR JOSEPH W. BAZALGETTE—*continued.*

DESCRIPTION OF THE MAIN DRAINAGE WORKS, AND CAPACITY OF THE DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT; INFLUENCE OF THIS ON THE STORM DISCHARGES—*continued.*

high level sewer varies from 4 feet 6 inches by 3 feet to two parallel sewers, each of them 10 feet 6 inches wide by 10 feet 6 inches high, with upright sides and a crown. The inclination varies from 30 feet to 2½ feet per mile, and its length is 13 miles, 19–22. The low level sewer commences at Putney and runs through Wandsworth, Battersea, Nine Elms, and Kennington down to Deptford Creek. The whole of that district is very flat, and the sewer is very flat, and that is the reason why it is not carried along the bank of the river. The outfall sewer is 11 feet 6 inches in diameter, with a fall of 2 feet per mile, 22. At Crossness there is a pumping station with a lift from 22 to 33 feet, according to the state of the tide and the condition of the sewage, with a 500 horse-power pump, and an auxiliary pump of 500 horse-power, which is used in time of storm. At Deptford there is a lift from the low level sewer into the outfall sewer of 18 feet, with engines amounting to 500 horse-power. At the banks of the Effra there is 200 horse-power provided for lifting the storm waters into the river in times of heavy storms when they are penned up by the tide, and there is another at Falcon Brook of the same power, which lifts from 6 feet to 12 feet. At Abbey Mills the lift from the low level sewer into the outfall sewer is 36 feet, with 1,140 horse-power; and the western district is lifted into the low level sewer 18 feet, with an auxiliary, in times of heavy rain, of 120 horse-power, making a grand total of 3,520 horse-power, nominal, 22–4, 136–40, 207. The Metropolitan Board of Works has the charge of the main intercepting sewers, and also of the main storm sewers (called main sewers in Schedule D. of the Act of 1855), and the districts boards (some 40 in number) have charge of the branch sewers under the general control of the Metropolitan Board. Their primary duty is to deal with small sewers, and see that the small drains or sewers from houses on the river bank are diverted from the Thames into the intercepting sewers in their districts. There are still some houses the sewers from which drain into the Thames, 36–40, 176, 12,816. The outfall sewers all discharge into reservoirs, one at Barking, and one at Crossness, the time of discharge commencing at high water and continuing for four hours afterwards. Barking was selected for the northern outfall because the sewage of a great portion of the Metropolis could reach there by gravitation, and so reduce the pumping. Crossness was selected on the south because for a distance of six miles, from Woolwich to Erith, there are no houses on the banks, and only a number of factories and works of an offensive nature. There was no other spot until Gravesend is reached, where so eligible a position could be obtained for the discharge of the sewage. To discharge it 15 miles further down, at Tilbury, would require a fall of two feet in a mile, which means lifting the sewage by pumps 30 feet, and the cost of doing this would be from 2,500,000*l.* to 3,000,000*l.*, and the pumping would represent another 1,000,000*l.* The cost of the works which have already been carried out (the system now in operation) has amounted to 4,000,000*l.*, which is exclusive of all the district sewers, and the proposed work on the storm discharges is also extra, 40–53, 55, 194–8, 12,950–4, 12,957*a*. He hands in a map, which shows a private scheme, proposed some time ago, for irrigating land with the sewage, 54. The Barking reservoir covers 9½ acres, and that at Crossness 6½ acres. Barking is 11½ miles, and Crossness 13½ miles, from London Bridge. Trinity high-water mark is 12 feet 5 inches above Ordnance datum, low-water is 7 feet 6 inches below datum, making a difference of 20 feet. Half tide is + 1·56 over datum. The bottom of the reservoir is + 2·75 over half-tide. The overflow weirs are 16·25 feet, or 3·75 above Trinity high-water; the available depth, therefore, is 13½ feet. The Crossness overflowing weirs are 2·5 feet higher than at Barking, and the available depth is 16 feet. The reservoir begins to overflow when the sewer is running half full. Barking reservoir will contain 35,000,000 gallons or 5,600,000 cubic feet. Crossness reservoir contains 25,000,000 gallons or 4,000,000 cubic feet, making a total of 9,600,000 cubic feet. In 1878, the quantity discharged at Barking altogether, including the average quantity of rain for that year, was, in 24 hours 13,120,000 cubic feet, which, in the eight hours that the reservoir has to store it, amounts to 4,373,000 cubic feet.

SIR JOSEPH W. BAZALGETTE—*continued.*

DESCRIPTION OF THE MAIN DRAINAGE WORKS, AND CAPACITY OF THE DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT; INFLUENCE OF THIS ON THE STORM DISCHARGES—*continued.*

During the discharge, the sewage flowing in is not stored, but flows through the reservoir, 55–63, 145-52, 12,668–84. The corresponding figures for Crossness are, total quantity discharged in 24 hours, 12,164,000 cubic feet, eight hours storage, 4,055,000 cubic feet, the two amounting to 8,428,000 cubic feet from the two reservoirs in eight hours, which leaves a margin over the actual capacity of the reservoirs, 64–8. The reservoirs are emptied each tide, 69–71. In times of excessive rain, when more flows into the reservoirs than they are capable of holding, there must be an overflow, just as there is at all the storm outlets into the river, and it must be far less objectionable at Barking and Crossness than in the Thames at London, 71–3. In the four years preceding 1878, the average annual increase in the quantity of sewage discharged was 14 per cent; he has not got the actual quantity since 1378, but has assumed that the annual increase since 1878 has been as great as it was prior to that year, 64, 100–10. The quantity of sewage discharged at Barking now (on these figures) would be in 24 hours 14,956,000 cubic feet, or in eight hours 4,985,000 cubic feet; and at Crossness the quantity would be 13,867,000 cubic feet in 24 hours, or 4,622,000 cubic feet in eight hours, making a total of 9,607,000 cubic feet, which on the average balances what the reservoirs are capable of holding. But as the flow of the sewage is not evenly distributed over the eight hours, the reservoirs may be overcharged, and are overcharged at times, even in dry weather. The Board of Works having foreseen this difficulty, had determined to enlarge the reservoirs, at a cost of 160,000*l.*, to the extent of fifty per cent., but objections having been raised to the position of the outfalls, and the Royal Commission having been appointed, the execution of this work has been deferred for three months, 75–6, 158, 170–5, 12,950–2. Some portion of the sewage of Acton, which is without the district mentioned in the Act of Parliament, drains into the Metropolitan system, and there are legal proceedings pending at the present time with reference to it. All applications from Acton and the surrounding districts to drain into the Metropolitan system have been invariably declined on the ground that the system is laid out to receive the drainage of a given area, and that area cannot be extended, 94–7, 202–4. Upon the margin of the area some districts have the right of sending their surface water into the Metropolis, and many make use of that privilege to turn in the sewage of their waterclosets. Great vigilance is used to prevent it. South Hornsey is one of the districts, 98–9, 177. The present quantity of sewage discharged at Barking and Crossness can be obtained, but it has not yet been worked out since 1878. The main intercepting system was not really completed until 1874, 100–10. At the time of a thunderstorm the quantity discharged from the storm outlets would have to be added to the total quantity discharged at Barking and Crossness to ascertain the total quantity which gets into the Thames; but as the main object is to get it into the river as quickly as possible to prevent the diluted sewage from flooding houses, the pumping stations pump the storm water direct into the river, and the quantity pumped could be ascertained; but it would only represent a very small quantity of the total water passing, 132–40. The mean high-water mark, which is the mean between springs and neaps, would be about 10·7 feet above Ordnance datum, 141–4. The discharge from the reservoirs begins at high water and continues for four hours after high water. In three hours the reservoirs are emptied and the sewage flows through the reservoirs into the river as it comes from the sewers for the remaining hour. The penstocks are then closed. A record is kept of the time of opening and closing at Barking, 145–52. Even when it is known that a large quantity of storm water is coming down, the penstocks are closed at the appointed time, and the reservoirs, when full, overflow into the river. It is impossible to allow the men to use their own discretion when they may leave the penstocks open or not. In times of storms the Thames and its tributaries are always much swollen, and it is a period when discharging sewage into it is really no nuisance. It is better, therefore, to allow the reservoirs to overflow than to continue discharging on the remaining two hours ebb, 154–8. He can ascertain, if required, the exact number of small sewers draining into the Thames, and the number

SIR JOSEPH W. BAZALGETTE—*continued.*

DESCRIPTION OF THE MAIN DRAINAGE WORKS, AND CAPACITY OF THE DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT; INFLUENCE OF THIS ON THE STORM DISCHARGES—*continued.*

of inhabitants, five years ago. To furnish the information up to the present time would necessitate a fresh survey of the river, 205–6. When a thunderstorm is local the Thames would not be in a heavy flood, but, as a rule, the Thames is in a state of flood in wet weather, 215. A statement of the quantity of sewage discharged at Barking and Crossness since 1878 up to the present time was handed in by Mr. Bidder in accordance with the promise made by witness (*see* Qq. 100–10). The total quantity for the four years is as follows:—

| Year. | Barking. | Crossness. |
|---|---|---|
| | Gallons. | Gallons. |
| 1879 - - | 33,616,848,827 | 31,065,965,556 |
| 1880 - - | 32,390,858,252 | 29,533,247,494 |
| 1881 - - | 32,632,794,334 | 27,223,090,538 |
| 1882* - - | 27,553,687,490 | 21,043,864,091 |
| Total - | 126,194,188,903 | 108,866,167,679 |

* Barking to 24th November. Crossness to 22nd November.

The fluctuation in the table is due to the rainfall to a certain extent, because a good deal of rain got into the sewers, and this is the reason why there is no continuous growth. (*See* Evidence, 12th Day, after Q. 6864.) He has had a table prepared which gives up to the present time the exact areas from which sewage is intercepted in square miles, the length of the main intercepting sewers, including branches, their dimensions, and inclinations on the north and south side of the Thames. The area drained on the north side is 48½ square miles within the metropolitan area, and 3·46 square miles outside the metropolis, making in all 51·96 square miles, say 52 square miles. On the south side the area drained within the metropolis is 51·21 square miles, and outside the metropolis ·57 square miles, making in all 51·78 square miles, now draining into the system. Of the remainder, viz., 16·57 square miles undrained, it consists mainly of agricultural land or nursery gardens, houses with large grounds attached, parks and commons, all of which have a very small population upon them. The sewage, if any, is either disposed of on the land itself or drains into the streams adjacent thereto. The sewage, he may say, is almost invariably disposed of on the land itself. This land is not likely to be built over, nor is it likely that it will ever come into the metropolitan drainage system. He hands in the tables, 12,494–502, 12,778–85, 12,804–15.

He will now proceed to reply to Mr. Baldwin Latham's criticisms on the capacity of the drainage system. The inference drawn from his (witness's) evidence in 1853 can hardly be accepted now, as at that time he had not prepared any scheme himself, and it was proposed by Mr. Morewood to intercept the sewage of 43 square miles by one sewer only of 10 feet in diameter, capable of discharging 19,000 cubic feet a minute; whereas his three northern outfall sewers when united in one are capable of discharging 33,000 cubic feet a minute. He deals with a larger area, but when reduced to the same area it will be seen that he has provided 50 per cent. more discharging power than the scheme propounded in 1853 provided for. He stated at that time that there would be an overflow upon 80 to 100 days in the year if that scheme was carried out, and Mr. Latham says if that was so the same state of things must exist now. This deduction is not correct, because he has given a larger discharging power in proportion to the area to be drained, 12,503–7, 12,746–65, 12,786–803. The western district was provided for when he carried out his system, because the sewers were made larger by 6 inches in diameter than was originally intended in order to take in the sewage from that district if need be. The amount of sewage to be intercepted on the north side amounted to 27,440 cubic feet a minute, and the western district gave 5,130 cubic feet a minute, making in all 32,570 cubic feet a minute; now Mr. Latham allows that the three sewers are capable of discharging 33,000 cubic feet a minute (each will discharge 11,000 cubic feet); therefore the outfall sewer is a proper size for taking off the whole of the sewage of the western district. Mr. Latham is therefore wrong in saying provision was not made for that district, 12,508–18, 12,746–65, 12,839–64. Mr. Latham's conclusion that although there were 29 inches of rain in 1875 none flowed off at Barking is based on two assumptions; one was, that the water supply was the same upon the north as upon the south, viz., 31¼ gallons her head instead of 30·4 on the north side, and also that during the years 1875 and 1876 he omitted to point out that the sewage of the western district had not then been diverted to Barking. He assumes that a considerable part of the sewage escaped into the river higher up than Barking. Taking the population in 1881 the daily discharge of sewage at Barking would be 77,739,032 gallons, which, deducted from the quantity discharged, namely, 89,404,916 gallons, leaves a surplus of 11,665,884 gallons, or 1,866,525 cubic feet for a rainflow for 51 square miles, which is equal to $\frac{1}{63}$ inch in depth for every day in the year. That represents 5·8 inches, or nearly 6 inches of rainfall running off at Barking, which is equal to nearly 12 inches falling. Mr. Latham's data are not correct, 12,519–23, 12,889–97. Mr. Latham, in alleging that in July 1876 there were 20 gallons per head leakage, has under-estimated the water supply per head on the south side of the river; he has not included the whole area by 24 miles, and has assumed that the 69,000 people residing on those 24 miles do not drain into the system. Now the actual discharge was at the rate of 46·88 gallons per head, and if the sewage proper, viz., 32·50 gallons per head be deducted, it leaves a difference of 14·38 gallons instead of 20 gallons. This is accounted for in the following manner:—One-fourth comes from manufactories and tanneries; one-fourth comes from the board's flushing; one-fourth comes from the flushing of the district boards, and the remaining fourth comes from leakage. He explains at length, by reading his Report on the inlets at Bermondsey, how the tanneries there take in water from the Thames and discharge it into the sewers, which causes much trouble to the Board as well as considerable expense in pumping, 12,524–33, 12,707–14, 12,804–26. The object in fixing the lowest part of the reservoir 2·75 feet above ordnance datum was to prevent the whole of the sewage being discharged at one time and to extend it over a period of two hours and a half, because it was thought better to let the sewage go down the river, and partially return when it would be more purified and diluted by the admixture of Thames water. The overflow weir is 5 feet 6 inches above the level of high water, so when the sluices are first opened there is at first a very rapid discharge from the reservoir, then having come down nearer to the tide, it empties more slowly, and is completely emptied in 2 hours 40 minutes. The gates are kept open longer to allow the sewage coming in to flow out, because the reservoirs are too small to take the entire quantity coming in, 12,567–77, 12,668–84. The reservoirs were not constructed with a view of carrying out any chemical process or deodorization in them, and he adds, there was no object in making the reservoirs large enough for the future population, because they can be added to now, or in 10 years time. The money would have been thrown away. As he has said before, the Board only awaits the result of this inquiry to carry out their work of enlarging the reservoirs, 12,578–9. In providing for double the maximum flow through the sewers he provided also for a quarter of an inch of rain, except in some of the outlying districts, when he allowed for one eighth of an inch only. He will supply the names of those places, 12,685–701, 12,839. The flow of the sewage not being uniform, owing to the distance some of it has to travel, the maximum flow is only 40 per cent. above the average. This he ascertained by an experiment made on the 12th July 1876, and to which Mr. Latham referred frequently, 12,702–12. In his Report of 1856, he gives the area on the north of Thames as 51·44 square miles, whereas it really is 50·21 square miles. He is, however, unable to say where the difference arises. The area of Acton, which contains 4½ square miles, is not included in the 50·21 square miles, 12,778–85. From Abbey Mills to Barking the three sewers are 9 feet each in diameter, and they each can discharge 11,000 cubic feet a minute. The 10 feet 3 inches sewer to Abbey Mills is capable of

SIR JOSEPH W. BAZALGETTE—*continued.*

DESCRIPTION OF THE MAIN DRAINAGE WORKS, AND CAPACITY OF THE DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT; INFLUENCE OF THIS ON THE STORM DISCHARGES—*continued.*

discharging 14,000 cubic feet a minute; but the 9 feet sewers above Abbey Mills have a discharging capacity of 3,690 cubic feet per minute in excess of the quantity they were intended to carry; and the flow of all three is limited below Abbey Mills, and they thus become of the right discharging capacity for the duties they were intended to perform, 12,786–93, 12,923–7. The weir in the sewers is placed about 12 inches from the crown of the sewer, so until the sewers are nearly full the storm outlets do not act. The sewers can, however, fill and run full even when the storm outlets are acting. A sewer discharges more when it is not running quite full than when it is running full as the frictional surface is less. The discharge when running nearly full would be 11,000 cubic feet, and when a foot from the crown the discharge capacity would be about the same. Mr. Latham has adopted a formula for discharging his sewer which gives rather a higher result, 12,794–803. In estimating the amount of sewage per head on the south side at 46·88 gallons, he took the population on the 51·78 square miles which drain into the metropolitan system as 1,113,000. None of that area drains direct into the river, 12,804–16. The water is taken in at the Bermondsey inlets for the tanneries from half tide to high water and down to half tide again, and the amount would be 4,000,000 gallons in 24 hours, that is to say, in the two periods of high tides, 12,818–26. From the table of the gaugings of the discharge of sewage at Crossness on the 12th July 1876, the weather being dry, there is, to his mind, nothing inconsistent with the opinion he formed that the flow is accounted for by the amount of water taken in by the tanneries, and from thence poured into the sewers, together with the water used for flushing, and that of the difference between his estimate and Mr. Latham's only one-fourth is due to leakage, 12,827–38. The western district sewage, it was originally intended, should be dealt with separately, and the Acton district never was intended to be included in the metropolitan area, nor does he contemplate taking it in now. The discharging capacity of 28,000 cubic feet was therefore thought sufficient; but, as he stated before, taking into account the addition of that district, and the future increase of the population, he provided a discharging capacity of 33,000 cubic feet per minute. The population at that time was 1,614,000, exclusive of the western district, and 1,766,000 including it; the contemplated population was 2,056,000 exclusive, and 2,353,000 inclusive of the western district. He will work out how much of the 28,000 cubic feet was margin for the increased population, 12,840–64. As further proof that the sewers are more than sufficient to carry off the sewage of the whole area, he had occasion from the 15th to the 19th May 1883 (only a few days ago) to divert the sewage from one of the three outfall sewers on the north side, and he very carefully watched the effect to see how high the sewage rose. In the middle level sewer when it contained the sewage of the high level in addition to its own supply it rose to a maximum height of 5 feet 2 inches, and in the low level sewer (there being some communication which equalized it a little, but not altogether) the maximum height was 3 feet 10 inches. His calculations showed that the three sewers during the time of maximum flow should be half filled with sewage, and the other half should be left for the quarter or eighth of an inch of rain. (He took the maximum flow to be double the ordinary or average flow). Now the quantity flowing through those two sewers at the time, instead of being half, was only one-third, so that in fact one of those sewers would carry off the whole of the sewage of London on the north side, assuming no rain, leaving two-thirds of his capacity, instead of one-half, and the sewers are, therefore, large enough to last to the end of the present century, 12,923–7.

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—Permission having been given to certain districts, not included in the Metropolitan area, to discharge their storm overflow into the natural outlets, such as the Wandle (for example), advantage has been taken by them to discharge their sewage into the streams and river. Where they have power, under the Metropolis Management Act, they take proceedings to stop it. But



SIR JOSEPH W. BAZALGETTE—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

there are other ways in which the Thames is polluted, over which they have no jurisdiction. The sewage of Stratford is discharged into the River Lea and flows into the Thames; at North Woolwich a few houses drain into the Thames, to connect which with the sewers would cost more than the houses are worth; Cold Harbour sluice, Beckton Gas Works outfall, and the shipping, all go into the Thames: and there is that which comes in above the outfall, 177–84. When designing the main drainage works, he thought, in selecting Barking for the discharge of the sewage, there would be a comparatively short period in which noxious sewage would remain in the river, and the question he had to deal with was that the Thames was a nuisance to the inhabitants of London. The lower reaches of the river at that time were not so important as they are now, and assuming that there is a nuisance growing up in the lower reaches of the river from the discharge of the sewage into the river at Barking and Crossness (though he does not admit the nuisance), the nuisance should be removed. 12,654–61. In the old times the nuisance in the Thames arose from the sewage in the water and upon the banks, and also from the deposit of the sewage at the bottom of the river, which gave off gases. It was, no doubt, aggravated by the length of time the deposit had remained there. He has never examined in hot weather the existence of smells in the water, as his sense of smell is not very acute, and he would not, therefore, detect it rapidly, 12,662–7. In the Report of Dr. Lethby, published as an Appendix to the Report of Messrs. Bidder, Hawksley, and Bazalgette, dated 6th of April 1858, the question of oxidation is referred to, and Dr. Lethby says that this may be obviated by defecting the sewage by means of lime and allowing the clear liquor only to be discharged into the Thames, or the sewage may be discharged in such a manner that it will mix with and be diluted by 200 or 300 times its bulk of river or sea water. The mischief which really results from the (then) present mode of disposing of the sewage is caused by the insoluble organic matters which collect upon the banks of the river near to the sewers, and there undergo perpetual putrefaction, 12,766–76, 12,907–12. From his own report of the 3rd April 1856 he reads extracts as to the various causes which combine to pollute the river. He concludes the report by saying that it is extremely undesirable, in a sanitary point of view, to cause sewage matter to become intermixed with sea water, and especially under circumstances which will occasion it to be brought up the river by the flood tide; but that if the sewage matter were poured into a much larger volume of fresh or freshened water in a running stream it would become immediately oxygenized, and cease to exist as a noisome and offensive agent. The experiments of Dr. Lethby and Dr. Odling fully confirmed his view, and the sites for the discharge of the sewage were, therefore, unhesitatingly selected at Barking and Crossness, 12,904-6. On page 116 of Dr. Lethby's Report, he says that the docks on the north side of the river which receive their water from the Thames below Blackwall are never offensive, while in the London and St. Katharine's Docks the water is always turbid, and in the summer time is offensive from the putrefaction of the mud. At the West India Docks the water is comparatively pure, and it is generally well stocked with fish. In the summer time the mud, however, undergoes putrefaction and kills the fish. At the East India Docks the water is still purer, and it is a rare circumstance for the mud to putrefy and the fish to be killed; while at the Victoria Docks the water is quite clear, fish are abundant, and the water and mud never show signs of decomposition or putrefaction. From this it would appear that the soluble or insoluble part of the London sewage is the cause of the mischief observed at the London and St. Katharine's Docks, and that it is quite innocuous by the time the water containing it reaches Blackwall. The organic matter does not decrease, but its condition is altered by the action of the air and by the agitation of the running stream. Those, therefore, who have looked upon the London sewage as an unchangeable log of wood floating up and down the river have taken a very erroneous view of the matter. So prone is the organic matter to undergo change and to complete its course of putrefaction, that it is doubtful if it exists as a putrefying body a few hours after its entrance into the river. During the time it has been traversing the sewers it has generally been so agitated

SIR JOSEPH W. BAZALGETTE—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

and broken up as to be in an advanced state of putrefaction. Almost all of the nitrogen has been changed into ammonia, and its sulphur into sulphuretted hydrogen, and then, when it reaches the Thames, it finishes the last stage of its putrefactive career by the rapid absorption of oxygen, and the formation of compounds that are comparatively inert, so that, partly by means of dilution and partly by the destructive powers of oxidation, the Thames possesses the means of self-purification which is fully equal to the contaminating injury to which it is at present exposed, 12,907. Taking the population for 1883 as given by Mr. Latham, and multiplying it by the water supply, it gives 9,690,000 cubic feet of sewage discharging into two ebb tides of 2,233,000,000 cubic feet of water at mean tides, which gives a dilution of 1 in 230, and that complies with Dr. Letbby's idea of dilution to effect purification, 12,908–15. He considers the river to be in a satisfactory state between Erith and Greenwich, and the statements which have been made have been very much exaggerated. Considering that there is no population, and that there are only chemical works in the neighbourhood of the outfall, no harm is occasioned by the discharge of the sewage there, and that there is nothing to complain of, 12,941–4. The sewage is very quickly diluted, and a mile or two from the outfall it disappears. It is no serious inconvenience either to the health, comfort, or enjoyment of the people who live on the river or on the banks. So far from people being poisoned by it who were in the "Princess Alice" accident, he has seen the water drunk at that spot, and there was nothing offensive in it, 12,945–6. Some of the members of the Commission have walked with him on the shore and found it quite clean. The statements he has heard in this inquiry have astonished him, as he has never discovered anything offensive until he got close to the outfalls. If the 4,000,000*l.*, which it is proposed to expend on the drainage works were handed over to him he could lay it out much more for the benefit of London by relieving London from floods or by making communication across the Thames below London Bridge, 12,947–54. If the sewage were discharged further down the river it would fall into a larger volume of water; but the water would be salter, and would be liable to create a nuisance, 12,955. An Act of Parliament was obtained, and the works were commenced, to carry the sewage to the Maplin Sands and utilise it there, but the scheme was not carried out, 12,953, 12,958–9.

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—Every precaution is taken to prevent solid matter getting into the sewers by careful scavenging, and by gulleys to intercept the solid matter which may flow into the sewers from the roads, such as shingle and sand. In dry weather there is not much accumulation in the sewers now, and the first effect of a heavy storm is to wash away any deposit in the sewers, 208–14. By the time anything solid in its origin is washed out of the reservoirs it is tolerably well mixed up with the water. Bits of bone and iron sometimes come down the sewers, but not often, 218–222. In 1850, the system of catch-pits was introduced in London for the purpose of preventing the road detritus and other heavy matter from getting into the sewers, and it has been very successful in doing so. At first they were of very defective construction, and a great deal of detritus overflowed from the catch-pits into the sewers. Between 1850 and 1880 they have been very much improved and very largely extended. The average amount of detritus removed from the streets annually is about 775,000 cubic yards (one cubic yard is equal to a ton). Of that quantity 616,500 tons are removed by scavenging by carts, 133,000 tons are removed from the catch-pits, and 25,600 tons are removed from the sewers. Of these quantities 40 per cent. is road detritus, 40 per cent. is water, and 20 per cent. is garbage from the markets, and refuse. The cost of removing the deposit from the sewers is very great, so it is to the interest of the Board to intercept as much as possible; and if the catch-pits are properly looked after, and are emptied from time to time, they answer very well, 12,582–6, 12,590–5, 12,605–9. A sample of sewage taken at the outfalls before the catch-pit system was introduced would not be fair criterion of the amount of suspended matter delivered at the outfalls after the introduction of that system, 12,587–8. He is unable to give any evidence about the mud banks and smells; he confines himself simply to the drainage system, 12,589. Besides the quantity of detritus intercepted, some may have passed through the sewers as sewage, but he is unable to give an estimate of the quantity. In 1878 there were in all 1,710 miles of roads made up as follows.

SIR JOSEPH W. BAZALGETTE—*continued.*

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS—*continued.*

| | |
|---|---|
| Macadamised roads | 1,338 miles. |
| Paved roads | 274 ,, |
| Paved courts | 61 ,, |
| Asphalte | 22 ,, |
| Wood paving | 15 ,, |

Upon these roads were put 307,700 tons of macadam flint or hoggin, and off the granite paved roads 39 tons were probably worn away in the course of the year, 12,596–609.

DISCHARGE FROM THE MAIN OUTFALLS AT IMPROPER TIMES.—When the sewers bring down more sewage than the reservoirs are capable of holding, there must be an overflow into the river, just as there is an overflow at all the storm oulets. In the beginning of 1881 the reservoirs overflowed on forty-three days at Crossness at the time of flood tide, and at Barking the number of days was greater, 71–5, 164–8, 12,928–39. An instance when it was reported that the overflow from the main outfalls continued after the four hours was inquired into, when it was found that there was a slight leakage from one of the penstocks. This was at once stopped, 153, 12,939. He is not aware that a discharge was going on six hours after high water on the 30th June 1882. It would be contrary to practice, and the men have very strict orders on the subject. Any dereliction of duty of that description, if discovered, is severely reprimanded, 159–61. In flood times, and when there are heavy rains, the sewage has been discharged before the beginning of the ebb tide; at other times the discharge begins at high water and continues for four hours after. The discharge can be continued if desired until the return of the tide. He will furnish a table giving the hours of discharge for the past eight years at Barking and Crossness, 12,668–84, 12,928–39. He now hands in Tables A and B, which show the number of days on which overflow before high water occurred at Barking and Crossness for the eight years from 1875 to 1882, in consequence of the insufficient size of the reservoirs or from heavy rain. The discharge of sewage on the ebb tide at Barking varied from three hours in 1875 to four hours in 1882, and at Crossness from 1875 to 1879 inclusive the sewage was discharged for three hours, and, subsequently, for four hours after high water, 12,928–30, 12,935–9. In 1882 the small number of overflows is accounted for by the frequent discharge of sewage at the Deptford Creek storm outlet, as he explained before (*see Questions* 12,564–6. *Discharge from the storm overflow outlets*), 12,931–2.

DISCHARGE FROM THE STORM OVERFLOW OUTLETS.—At Deptford Creek the sewers which pass under it have an overflow for storm waters into the creek. When in times of storms the quantity the sewers are capable of holding is exceeded, it rises up in pipes, under pressure, opens some flaps into the creek, and the storm waters are thus discharged into the creek. This is in addition to the overflow from the main sewers into the intercepting sewers. A similar contrivance exists in the River Lea to relieve the northern outfall, 19–21. There are 35 outlets on the north side of the river for the discharge of storm water into it, and 12 on the south, but owing to their low position, at certain times of the tide they cannot discharge into the river, and the low lying districts in consequence are subject to floods. Serious complaints have been received from Pimlico and Battersea of the flooding of the basements by the overflow of the sewers which are dammed up by the tide at high water during heavy floods. To remedy this difficulty the Board of Works have determined to spend 1,500,000*l.* in constructing storm relief sewers which will carry off the storm water from the higher districts and force it by pressure into the river, thus relieving the low lying districts of the pressure of storm water from the high districts. One such sewer has been constructed in the Fleet Valley district, with very satisfactory results; another is being made at Vauxhall Bridge; and others will follow, 24–34. A record is kept of the times the overflows are opened at Deptford Creek and the River Lea, but not of the others. At Deptford the number of days of overflow between 1872 and 1879 was as follows:—

SIR JOSEPH W. BAZALGETTE—*continued.*

DISCHARGE FROM THE STORM OVERFLOW OUTLETS—*continued.*

| | | |
|---|---|---|
| 1872 | 21 days. | |
| 1873 | 15 ,, | |
| 1874 | 9 ,, | |
| 1875 | 20 ,, | |
| 1876 | 19 ,, | |
| 1877 | 30 ,, | a very wet season. |
| 1878 | 17 ,, | |
| 1879 | 21 ,, | |

That, of course, was only during a portion of the day. There is a lower flap which is not self-acting, and which is opened by hand in times of very excessive storms, when the upper flaps are not sufficient to carry off the storm waters, 113–20. He can obtain the same particulars for the period from 1879, 121. When the High Level Sewer, is flooded it escapes over the weirs into the rectangle sewers, and it then goes into the middle level sewers, and from there into the low level, whence it escapes into the Thames at low water through the storm overflows. The matter which overflows would be mingled sewage and water. At certain times of the tide the storm water is penned back, and that is the reason why the Board is constructing the storm relief sewers, 122–31. He hands in a table giving the number of times overflows have occurred, and of which a record has been kept, from some of the storm overflows. It is impossible to give the return from them all; in fact it is only at the pumping stations, or where some one has been placed in charge that the information can be given; viz., on the south side at Deptford Creek, Vauxhall pumping station (the Effra) and Battersea (Falcon Brook); and on the north side at the Western District pumping station, and at the River Lea, 12,555–6. The records from these five places are very incomplete, and the causes of the overflows cannot be given always. The average number of overflows for the ten years from 1872 to 1882 at the five stations is as follows:—

| | |
|---|---|
| Deptford Creek | 23·09 |
| Vauxhall Pumping Station | 20·66 |
| Battersea | 18·33 |
| River Lea (Old Ford) | 20·00 |
| Western Pumping Station (Pimlico) | 30·60 |

The average annual rainfall for the same period was 26·40 inches. The whole of the overflow is, of course, not sewage. It would vary with the different rains very much. With very heavy and continuous rain, the overflow would be very highly diluted, 12,557–63. The excessive discharge at Deptford in 1881 and 1882, as shown in the table, is the result of certain instructions given to the flapkeeper to discharge the sewage from the overflow outlet whenever the barometer was falling with an appearance of rain, because in 1879, he waited until the sewers were full, and the sewage when discharged burst out with such force as to blow away the wharf wall opposite to the outlet. (He produces a model of the high level sewer coming down to Deptford Creek, and explains the method by which it is worked.) The flapkeeper has discharged the sewage more frequently than was expected, but he has acted rightly, no doubt, in doing so, 12,564–6, 12,931–2. He hands in a complete list of all the storm outlets on the north and south side of the river, with the level, size, and exact position of each given thereon, of which all but two are self-acting, 12,726–9, 12,898–901.

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER.—Putting a float into the river at high water as compared with low water makes a difference of about twelve miles, that is to say if a float be put into the river 12 miles lower down than London Bridge below high water it will, upon an average of tides, float up to London Bridge. The sewage, therefore, having been put into the river at low water for some years and flowing up, caused a nuisance to the river, 5–8. The average contribution of the river to the sea (or the mean flow) is 84,500,000, cubic feet in each ebb tide. The discharge of tidal water past the outfall is 2,148,713,000 cubic feet, the two together making the water that flows down each ebb tide, 2,233,213,000 cubic feet. The tidal water is water which has flowed up and come down again. The proportion of fresh water to tidal water, roughly speaking, is about four per cent. The volume of sewage discharged at the two outfalls is 14,000,000 cubic feet, 75–85. The volume of water in the river at the outfalls as compared with the volume of sewage discharged into the river may be taken as 150 to 1, 87. Captain Burstal and he made a number of float experiments (assuming that the sewage was a solid block like a float) to ascertain what would

SIR JOSEPH W. BAZALGETTE—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

be its action if carried down by the river two hours after high water. On the 13th July 1851 a float was put into the centre of the river, two hours after high water, opposite Barking creek. At low water it had reached 11¾ miles below the creek, and returned on the next flood to one mile above This was a period of spring tides. As the neaps came on it continued to work lower down at each succeeding high water, and on the 24th July it was 13 miles below Barking Creek at high water. As the floods became stronger it worked up the river again, and on the 29th July it was five miles below Barking Creek at high water, having worked up nine miles from high water neap tides to high water spring tides; the excess of the ebbs over the floods being five miles in 14 days. On the 6th August 1851 a float was put in at exactly the same spot, the tides being then lowest neaps, and on the 12th August it had worked up to 6¼ miles above Barking Creek at high water. On the 21st August it was 9½ miles below Barking Creek. The excess of ebbs over floods in this case was about seven miles in 14 days. Roughly speaking, it may be assumed that a substance in suspension works up the river about one mile per day at each high water as the springs strengthen, and down the river two miles a day as the tides fall off. The sewage however is not like that solid substance. If it were so, the effect would be that sewage discharged at London at low water daily would in a fortnight produce such a concentration of sewage that the stream would be one of sewage instead of one of water at low tide, 86–91, 12,902–3. The float was kept in mid-stream during the time it was in the river, and it will presently be shown what the actual course of the sewage in the river is, and that a very short distance below the outfalls it ceases to be objectionable, 185–7. Experiments have been made of the velocity of the river at different depths, and with different materials to ascertain the difference in the surface mean velocity. The floats were weighted, so that they were affected by whole depth of the tidal flow, 216–7. In 1866, when Captain Burstal was directed by Government to make the float experiments and to test the original experiments, he received instructions from the Metropolitan Commissioners of Sewers to make them in concert with Captain Burstal. They supervised the movements of the floats, and checked the results, but did not follow them up and down, 12,581–2. The oscillation of the sewage is spread over a distance of about 12 miles from high water to low water, as judged by the movement of the floats. With a spring tide it would rise higher up the river, and with a neap tide it would go further down, 12,610–25. Prior to the construction of the works, he formed an opinion that the sewage would be rapidly destroyed by dilution and oxidation after its discharge into the Thames, and that it would never reach the sea in the form of sewage. This was the result of general observations and not of any special experiments, and is embodied in several reports which he will produce at a future date, 12,626–38, 12,652–3, 12,902–7. The question as to how far oxidation would assist to deodorize the sewage, both as regards volume and time, was taken into account when designing the main drainage works, and the solid constitutent parts of the sewage going into the Thames were also fully considered, 12,639–51, 12,916–22. He now proceeds to read at some length extracts from his Report, dated 3rd April 1856 on the distribution of sewage from oscillation, pages 8, 9, and 10, and he describes the course of the float experiments in 1851, the result of which he has stated previously. (*See questions* 86–91). 12,902–7. Sewage discharged at high water at any point is equivalent to its discharge at low water at a point 12 miles lower down; therefore the construction of 12 miles of sewers is saved by discharging the sewage at high water instead of at low water, 12,903. He reads a further extract from his Report showing that he calculated the solid matter at 250 tons a day for the prospective population of 3,500,000, taking both sides of the river, the existing population at that time being 2,500,000. Dr. Tidy's estimate of 294 tons for a population of 4,000,000, viz.: the dry matter in the fæces at 97 tons, and the urine at 197 tons a day, is a little in excess of his estimate, if the dry matter in the urine is taken as forming a solid deposit. Messrs. Bazalgette Law, and Chatterton, in their Report of 15th April 1878, assuming 23 grains of solid matter to the gallon, estimated the total solid matter discharged into the Thames from

SIR JOSEPH W. BAZALGETTE—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

120,000,000 gallons of sewage at 176 tons per day. Dr. Tidy gives from 23 to 25 grains per gallon as the quantity of solid matter in normal sewage, showing that our estimate of 250 tons was in excess, 12,917–22.

POPULATION TO BE PROVIDED FOR.—Mr. Latham's estimate of the existing population, he is disposed to agree with, and that there is an increase of 500,000 people up to the present time. But in the capacity of the intercepting sewers, provision has been made for double the average flow, which is the same thing as the ordinary flow for double the population, and that double flow was over estimated. Instead of being double it is only 40 per cent. more in consequence of the want of uniformity of the flow, and this he overlooked in making his design. Now the result of that is this, assuming that the population at the present time to be, as stated by Mr. Latham, 3,975,468, and assuming the maximum flow to be 40 per cent. upon that, it would be equivalent to a population of 5,565,656 with a uniform flow; but the population actually provided for with a uniform flow is double what was provided for at the time of Messrs Bidder, Hawksley, and Bazalgette's report, being 6,897,000, so that there is a balance of 1,331,344, supposing the flow to be equal; but making allowance for the additional 40 per cent. that gives room for an additional population of 950,960 (nearly 1,000,000); that is to say, with the 40 per cent. flow upon a total population of 4,926,400, or nearly 5,000,000. That population, according to Mr. Latham's table, would be arrived at in the year 1896. He does not quite agree with Mr. Latham's table as to the increase of population, for London is getting filled up, and will not increase. It has been shown that it is not increasing so fast as it did formerly, 12,534–6, 12,685–711. In his Report, dated the 3rd April 1846, he says the amount of sewage proposed to be intercepted from the more closely inhabited districts has been estimated upon data which makes provision for the increase of future generations. Thus where the population as at present existing exceeds 30,000 to the square mile the actual numbers are estimated for, and where it is less, allowance has been made for that number in order to provide for future increase. The supply of water per head has been reckoned at five cubic feet per diem, being on a more liberal scale than now actually obtains, and of this quantity it is contemplated that one half will pass away during six hours of the day, 12,905. In those parts of the suburbs which are not likely to be built upon he provided for a possible increase of population varying from 10,000 to 20,000 to the square mile, instead of 30,000, 12,903.

RAINFALL TO BE PROVIDED FOR.—With regard to Mr. Symons' evidence on rainfall, he believes his calculations to be wrong; in the first place he based those calculations upon years subsequent to 1856 when the rainfall. Mr. Symons admitted, was excessive. Then he (witness) stated, in reply to Q. 9, that the number of days upon which (prior to 1856) a quarter of an inch of rain fell was 25, but he referred to rain running off, and he showed that provision was made for a quantity equal to a quarter of an inch running off. The total quantity of rain running off in the Savoy Street sewer was shown in Messrs. Bidder, Hawksley, and Bazalgette's Report by gaugings to be 68·5 per cent. of the total rainfall in the 36 hours when rain fell, and in the case of the Ratcliffe Highway sewer was 48 per cent. of the total rainfall, so that is conclusive evidence that the rainfall of 0·4 is not likely to yield more than a quarter of an inch. So when 0·4 of an inch of rain falls you expect to get a quarter of an inch running off through the sewers, and in excess of that to get an overflow. Now there were only 12 days upon which more than that quantity fell, 12,537–9, 12,734–45, 12,865–884. Then Mr. Symons divides the quarter of an inch falling in 24 hours into hundredths of an inch per hour, and assumes $\frac{4}{100}$ths of an inch running off in one hour to represent the same thing as a quarter of an inch running off in 24 hours. This is most erroneous, for that amount falling on a dry surface, and in many cases upon a very small surface would really produce no discharge into the sewers at all, and to say that it would produce an overflow, is absurd. If that argument is correct you might make it infinitesimal, and say that $\frac{1}{6000}$th part of an inch falling in one minute would fill the sewers, whereas it would not affect them, 12,539–45, 12,715–25.

He has taken 104 days in 1877 upon which Mr. Symons has said that 0·4 of an inch fell, or over, and the assumption as it stood was that upon those 104 days the sewers must have been full and some overflow taken place. He has analysed this, and finds that—

| | | | | |
|---|---|---|---|---|
| On 40 days that quantity fell for one hour only in the | | | | day. |
| ,, 24 | ,, | ,, | two hours | ,, |
| ,, 16 | ,, | ,, | three ,, | ,, |
| ,, 15 | ,, | ,, | four ,, | ,, |
| ,, 3 | ,, | ,, | five ,, | ,, |
| ,, 5 | ,, | ,, | six ,, | ,, |
| ,, 1 | ,, | ,, | eight ,, | ,, |

If he adds up all those hours together it reduces the 104 days to 10·37 days of 24 hours each in which the rain was actually falling.

On the same principle the results for 1878, 1879, and 1880 are given below.

In 1878 there were 8 days of 24 hours each in which that quantity was falling; in 1879 there were 10·4 days, and in 1880 there were 8·4 days. The periods for which the rain fell for a long time decrease in each year. It follows therefore that very few, if any, of the rainfalls mentioned by Mr. Symons were of sufficiently long duration to contribute to the sewers a quantity equal to a quarter of an inch running off in them from the whole metropolitan area at the same time, 12,546–9. In many cases where rain has fallen two or three hours in a day there have been dry periods between the showers, and the rain has dried and evaporated. Then these rainfalls are recorded at Kew, and it does not follow that the rain fell uniformly over the whole of the Metropolis at the same time. It is more than probable, on the contrary, that none fell upon the whole area upon any single occasion. He has prepared a comparative statement of the rainfall at Kew and at Greenwich for the same period, which he hands in, and it is curious to note that they do not agree in any single instance. It shows that there is the greatest inconsistency in the fall as might be expected. An ordinary rainfall does not cover the whole 117 miles, the rain cloud passes over from one part of the metropolis to the other, discharging first at one hour in one part, and at another hour in another part. He has in the table at the end worked out very carefully the number of days, and the number of hours per day in which 0·4 of an inch fell, and in which one-tenth of an inch of rain fell in one hour. In 1877 the rainfall lasted at the rate of one-tenth of an inch per hour for two days upon the average, equal to 48 hours in the year; in 1878 for 2·8 days of 24 hours; in 1879 for 2·5 days of 24 hours; and in 1880 for 2·5 days of 24 hours, 12,550–2, 12,885–8. Rainfall of $\frac{1}{100}$th of an inch, or of $\frac{4}{100}$ths of an inch in an hour in dry weather would scarcely do more than wet the surface. It would not charge the streets with so much water as a water-cart, as that throws the water more heavily on the surface, but the cart does not cover so large an area, 12,553–4. Two inches of rain in an hour have been known to flood the sewers, and at Paddington, in one instance, building operations had to be stopped on account of the rising of the sewers during very heavy rain, 12,715–25, 12,940. A very much larger proportion of rain finds its way into the sewers in the most populous parts of London than is the case in those areas which are less urban in character. The effect is not felt in the sewers the moment rain begins to fall, because it takes a certain time to get in, but the rain will continue to run through the sewers after the fall has cased, 12,738–45. The 28,000 cubic feet per minute discharging capacity allowed for an eighth of an inch of rainfall upon 11 square miles, and a quarter of an inch of rainfall upon 27 square miles in 24 hours. He did not assume that it would fall in any given time, but at some period during the 24 hours. If it fell in half an hour he would qualify that by saying not over the whole area, as it would then be a thunder shower only. The rainfall provided for was an eighth, or a quarter of an inch, running off in the sewers divided over a period of 24 hours, 12,865–74. Rain sometimes falls as slowly as $\frac{1}{200}$th of an inch in an hour, 12,875–84. In his Report of the 3rd April 1856, he stated that it was proposed to intercept in the urban districts a quantity equal to a quarter of an inch running off, which is equal to about $\frac{1}{100}$th of an inch per hour; any amount in excess of that being discharged into the river by the drainage sewers. In the more thinly populated districts provision was made for only one-eighth of an inch running off, 12,903.

SIR JOSEPH W. BAZALGETTE—*continued.*

RAINFALL TO BE PROVIDED FOR—*continued.*

## Mr. GEORGE CHATTERTON.

Civil Engineer and Associate Member of the Institution of Civil Engineers.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He has been professionally engaged very frequently on the Thames since May 1877, in taking soundings and sections, more particularly in the neighbourhood of the main outfalls for the West Kent Main Sewerage Board, by whom he was employed as Assistant Resident Engineer. His work was quite independent of the metropolitan system. Their outfall is near Little Powder Creek in Long Reach, 12,960–8, 13,129–32. He was taking soundings only during the last three hours of the ebb tide in Long Reach, and in that way he had a very good opportunity of judging of the condition of the river when the metropolitan sewage would be passing down. It reaches that part of the river in three hours. There was no perceptible smell of any kind, but there was an indication of the sewage. By watching the river very closely upon a very calm day, he noticed corks and bits of vegetables, and traces of grease which would float upon the surface, but there was no possible means of detecting any large bulk of sewage by the nose or the eye, 12,969–70, 13,063–4. He does not agree with Mr. Latham that the river would become noxious at a temperature of 65°. It must be near 70° than 65°, because according to the tables Mr. Latham handed in, the temperature of 65° was reached upon 19 days in June 1877, 25 days in July, and 30 days in August; and during those three months even when the temperature was above 65°, he never heard of a complaint nor noticed anything offensive in the water. The same absence of smell and perception of sewage applies equally to the autumn months, 12,979–82, 13,063–4, 13,152–7. In 1878 he was engaged upon the river on 37 days, and except at the outfalls he never smelt the river of sewage. His sense of smell is as good as most people, 12,987–9, 13,169–86, 13,200–17, 13,229–37. On the 23rd of November 1878, he went down the river with the members of the Metropolitan Board of Works to ascertain the condition of the river, in consequence of the complaints made at the time of the "Princess Alice" disaster. There was a very disgusting discharge of tar refuse from the outfall at Beckton, of which he obtained a sample, and it was analysed by Mr. Keates. It was disgusting, and had a strong tar smell, and from its appearance he thinks it was likely to be a deadly poison. On the day of the disaster, a very severe fire occurred at Messrs. Price & Co.'s works, which might have accounted for the offensive smell on the water at the time of the accident, 12,990–2, 13,187–92, 13,194, 13,197–9. In 1879 he was frequently upon the river taking soundings, and he also took the temperature of the water in Long Reach. In May it was 62°, and the condition of the river was very good. On the 18th July, the temperature was 67·8°, and he has never noticed any smell from the sewage in that part of the river when working there, 12,933–4. In 1882 he was 59 days upon the river, and on the 22nd May he went to Barking and traced the discharge down the river. When the sewage first comes from the outfall, the smell is most dreadful and most sickening, and never can be forgotten. At a quarter past five he put a float into the middle of the sewage immediately off the outfall. In half an hour the float was abreast of the lower portion of the reservoir moving slowly. He collected samples of the water or sewage in test-tubes, and it smelt strongly. At 6 p.m. the float was opposite Lawes Chemical Works, and particles of grease and bits of vegetables showed that something had been discharged into the river. There were traces of sewage three-quarters of a mile below, but mostly in the shape of floating particles. At this point there was no smell of sewage in the air unless the water was shaken up in a test-tube, 12,996–13,008, 13,200–17, 13,229–56, 13,371–98. At a mile from Barking the water when shaken smelt faintly, as it did also a quarter of a mile further down. The float was then to the south of mid-channel. There was no smell in the air then. Off Half-way House, the float was 100 yards from the south shore, and there were the same traces of sewage, but the solid particles of sewage had disappeared before Crossness was reached, and the water when shaken had no smell, 13,009–13. The float was 200 yards from the Crossness Quay Wall, a little below the outfall, and off the Belvedere Guano Works the water smelt when shaken, but there was no smell in the air until Johnson's Fish Manure Works were reached, when the smell from the works was worse than usual. At Rainham Creek, traces of sewage were

## Mr. GEORGE CHATTERTON—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

visible setting over the north shore, but there was no smell, 13,014–22, 13,273–4. Off Coldharbour Point, the float was 200 yards from the north shore, and there were vegetable particles visible. He finally lost sight of the sewage opposite the Royal Hotel, Purfleet, seven miles from Barking, 13,023–32. The evening was most favourable for tracing the sewage, being calm and bright, 12,996, 13,029, 13,036, 13,265–6. There had been little or no rain for the sixteen days prior to the 22nd May at Greenwich, 13,037–8. In 1882 he took a number of samples of the water, which have been analysed by chemists. *He hands in* a plan showing the position of those samples, and a cross-section of the river showing the exact spot and state of the tide at which each sample was taken. (*See* Appendices A., K., 1 and 2), 13,039–42. During the whole of 1882 for a reasonable distance below Barking and Crossness, there was no smell from the water, even when its temperature was 65° or 66°. He tried every possible means to detect it by smelling the water with his face only one inch from it, and going astern of a screw steamer. Even the fisherman, who are the first to complain, admitted there was no smell last year, 13,043–8, 13,200–17, 13,229–33. He has seen offensive matter matter discharged from the Beckton outfall recently, and on the 3rd of July he noticed a large quantity of sewage discharging from Bow Creek at low-water. That was West Ham sewage brought down by the River Lea. He has seen refuse coming from the factories, but never in any large quantity. A good deal of refuse is pumped into the river from barges also, gas-works refuse from the works above Vauxhall Bridge, and leakage from paraffin ships, 13,049–55, 13,275–85. On the 27th July he could not distinguish the Barking sewage 1,000 yards off. The smells from the factories on some days in that month were very bad, 13,056–8. A good deal of sewage is discharged into the Thames above London Bridge, and on the 15th August he saw some very strong unpurified sewage discharged into river at Chiswick. A sample was taken by the chemists, 13,060–2. He hands in a table showing the gaugings taken at Seething Wells by Mr. John Taylor, Engineer to the Lambeth Water Company, for the month of May 1882. The height of the Thames at this place above summer level is also given. There was not much water coming down at the time he was engaged on the river. The following figures show the quantity on the days he was examining the river:—

| | | | |
|---|---|---|---|
| On the 20th May 1882 | - | 577,000,000 | gallons. |
| ,, 21st ,, | - | 601,000,000 | ,, |
| ,, 22nd ,, | - | 653,000,000 | ,, |

The greatest quantity in the month was 1,697,000,000 gallons in 24 hours.

The mean daily flow is 833,000,000 gallons.

(*See* Appendix A.L.), 13,071–7. He has examined the sewer outfalls, and for any person working in the immediate neighbourhood of any one of them there would be a local nuisance. He hands in a plan of Erith, on which the outfalls are marked. (*See* Appendix A.M.), 13,097–8, 13,106. The mud at Messrs. Beadle's wharf, close to which a 15-inch sewer discharges into the river, remains uncovered by the tide for three hours. He has seen sewage discharging from that sewer of the worst kind, because it is old stagnant sewage, which is far more objectionable than fresh sewage, 13,098–105, 13,110. The most important sewer (marked C. on the plan), discharges at the flour-mill close to the causeway, and runs over the mud left there in a most disgusting state. He found a quantity of sewage there which had been deposited by the previous tide. The mud all along that part is fouled by the Erith outfalls, of which there are a good many, 13,110–3. There are 31 factories on the river which carry on noxious trades. They emit very bad smells, and the worst are those on the north side of the river between Erith and Woolwich. He has not noticed any noxious discharge from these factories, except from small pipes in a few instances, and at Beckton, 13,118–28. All his details as to temperature of the river are taken from his level books, in which he has copied the records from those at Greenwich, and if necessary, he will produce that information from 1844 to 1879, 13,152, 13,340–3, 13,400–4. In 1878, out of the 37 days, he was on the river a good many of those days were prior to April, and on business unconnected with this Sewage Inquiry, 13,168–86. The state of the water in November 1878 would be no criterion of the state of the water at the

MR. GEORGE CHATTERTON—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

time of the "Princess Alice" disaster, but from its condition, the Board of Works were satisfied from the report of Mr. Keates, that there was nothing in it to poison those who were drowned in September, 13,187–92. The sewer at Beckton is egg-shaped, and about 2 feet 6 inches high. It is the worst place he has been in in his life, and the foreshore is the most disgusting condition. The smell coming from there is a gasey kind of smell, in fact a heterogeneous collection of smells, 13,193–4. His original notes for 1882 on the condition of the river he has not got, but they are contained in the proof he produces, 13,208–17. He has noticed a great deal of bubbling in the Thames off Jenningtree Point, in Erith Bight, and in Long Reach, on summer evenings, which he supposed were in some way the result of putrefaction, but on smelling them he could not perceive any odour coming from them. He has noticed them also when sounding, and, strange as it may seem, he has seen bubbles rising from a sandy bottom. He thinks the bubbles are harmless, and that no nuisance arises from them, nor does he believe that the patches, referred to by witnesses, which rise to the surface are a nuisance, 13,218–28. He does not think that when he followed the sewage on the 22nd of May, that the circumstances were favourable to his case, because he was kept for three-quarters of an hour in the middle of the sewage, before it began to run away, and so he worked in an abnormally large quantity of sewage. More is discharged in the first hour than afterwards. Had his float got out of the sewage earlier, and gone off with the tide, then the experiment would have been more in his favour, 13,233–58. The sewage is discharged through a culvert by raising the penstocks in the reservoir. The sewage rushes out at first very rapidly, and when it reaches a sufficient level, it falls gradually with the tide, taking four hours to discharge. The level of the weirs of the reservoir is 16·50 feet above ordnance datum, 13,259–64. The passage of a steamer through the sewage would not have the same effect as shaking a sample in a tube, because the smell has some space to disperse in, whereas in a tube the top is closed. Nevertheless to sit in a boat behind a steamer is a capital way to smell the river, 13,267–72. The condition of the river in November is better than it would be in October, on account of lower temperature, and also on account of the greater quantity of water coming down, as a rule, 13,330–2. In August and September 1882, he was taking soundings from half a mile above the Corinthian Yacht Club to half a mile below Messrs. Easton and Anderson's Works, and he took 44 cross-sections of the river between those two points. The sections were 400 yards apart, and his level books will give all information as to distances, dates, &c. These he will produce for the inspection of the Commission. (These were subsequently handed in for examination), 13,333–43. He can, speaking generally, distinguish between the smells from the various factories on the river, and with practice they can easily be distinguished. He has never smelt the sewage at the same time as he has smelt the factories, but he thinks he could detect the difference between the sewage smell (if he were just below the outfalls) and the factories smell, 13,362–72. The sewage of the 507 undrained houses in Erith, being concentrated as it is, will cause a nuisance when discharged upon the middle of the mud at Erith, and would account for the complaints made by those men who were excavating a channel for Mr. Beadle, 13,373–9. There was no smell from the Thames in Erith Bight in 1882 he is positive, and every one in Erith to whom he spoke on the subject agreed with him; nor was there anything offensive. He considers that Erith Bight is a very pleasant place to spend the summer in, 13,380–5.

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—He had to take foreshore sections between high and low water, and he never found the mud differed from ordinary Thames mud or any other mud, nor was it more disgusting in smell. This was over six miles from Crossness. He has been down in that part of the river frequently each year since 1877, and he does not think it is possible, as far as the eye or the nose is concerned, to detect any change in the mud upon the foreshore. It has not changed in the slightest. Owing to the extensive dredging operations which have taken place in Long Reach during the last two years, the river on the

MR. GEORGE CHATTERTON—*continued.*

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS—*continued.*

north side has been much deepened, and the set of the tide in consequence, is a great deal more on the north side now than it formerly was. There is no accumulation of mud taking place on the south side, 12,971–77, 13,133–41, 13,345–50. In 1878, he examined the banks and saltings all the way down from Greenwich to Yantlet, more particularly on the south side, with the view to see how much they had been washed away. To the best of his belief, there is no difference between the mud at Erith, and the mud at the mouth of all the creeks down the river. He could detect no difference. It is light coloured at the surface, and black below, 12,983–6, 13,065–70, 13,161–7. He obtained samples of Thames mud while taking soundings, but he saw none which had the filthy appearance described by some witnesses. In Erith Bight, the mud is slimy and sloppy, and he would not care to have to work in it. It is certainly lighter in colour than the mud in the river Mole, 13,065–70. The accumulation of mud at Erith Causeway is caused by the slack water, for wherever there is slack water in any part of the Thames for any lengthened period, there must be a deposit, because the suspended matter goes to the bottom. Now the river at Erith Causeway is, of all parts, the slackest. On an ebb tide, at three hours after high water, there is slack water there, and at three and a quarter hours after high water, there is a considerable eddy tide opposite the Corinthian Club causeway, of one and a half miles an hour. At the pier there is never any tide up, as the causeway lies between two currents, one going up, and the other going down, and at no time of the tide is there any considerable current over the causeway. There are some abnormal conditions at work there from the enlarged sectional area. If you integrate the whole cross section, and add the whole tide running in one direction, and subtract the eddy tide running in the other direction, the true mean velocity of the stream would be obtained, 13,085–96, 13,405–8. In order to bring barges up to the coal wharf below Erith Pier, a channel has been excavated in the mud, and to keep it clean, a tank has been constructed which fills at high tide and is discharged at low water, to flush the mud out of the channel; this, however, is not sufficient, and several men are kept constantly employed in trying to clear away the mud, 13,106–9, 13,386–8. The Club Causeway is constructed on piles, which allows the water to have free passage through them. There is, therefore, no local accumulation of mud there. The town causeway is a solid groyne running out, and the mud is heaped up on the ebb side. The construction of that causeway no doubt adds to the accumulation of mud at that place, 13,114–7, 133,51. Every time he took soundings, he took a sample of the mud and examined it to see if it had any smell, as he wished to become practically acquainted with the character of the river before the West Kent sewage was discharged into it. He was taking observations frequently in May 1877, and from June to the end of the year he was wholly employed on the river, 13,142–51, 13,158–60. His dates he gets from his level books, which only show where the mud is. He has no notes or memoranda of his soundings, but will produce his books if desired, 13,152–60. In 1878 he was engaged by the Metropolitan Board of Works to make observations in connexion with the Mud Inquiry, and a good many of the days he was on the river in that year were prior to April, 13,175–86. Prior to 1877 he had no knowledge of the state of the mud in Erith Bight, but in 1878 he drove a tube into the mud at Erith 10 ft. deep. There is a slight difference in the colour of the mud along the Bight, but there is no great difference in the mud near the causeway as compared with that in other parts of the Bight, 13,310–12. He has no experience of the mud there in 1877. In 1878 he was a dozen times between Purfleet and the outfall, but has no record of the number of times he was in Erith Bight. In 1879, 1880, and 1881, he was very seldom there, but in 1882 he was there very frequently from May to November. Out of the 59 days he was on the river in that year, he was working 45 days in the neighbourhood of Erith. Some of the sections he took were in that immediate locality, 13,313–29. There is a slight difference between the mud at the Corinthian Yacht Club causeway, and the town causeway, which can be detected by the eye. It is slightly darker and more compact at the Club causeway, and it is due he thinks to the stronger current there, which washes away the finer particles. There is

## Mr. GEORGE CHATTERTON—*continued.*

### Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

a difference in the texture of the mud, if he may so call it. He has been on Erith Pier at ebb tide and has seen the deposit of mud there. The accumulation of mud at the town causeway is due to its bad construction, and is generally acknowledged by the Eirth people to be so, 13,346–51. He is aware there is a deposit of mud on the lower side of the causeway, but from two feet to two and a half feet below its level. He would not be surprised if its depth was 6 to 8 feet, as he has found it to be 10 feet in one place, 13,352–4. In spite of that, he believes it to be ordinary river mud, and does not think it is slimy, nor is he aware that Mr. Beadle in his evidence stated it was so, 13,355–9. The mud smells where the Erith outfall is situated, but, taken as a whole, it smells no more than the river mud, which always smells a little. On this point, scientific witnesses will be able to give evidence of a more reliable nature than he can do, 13,360–1. No doubt there is a tendency to silt up at the place where the flushing takes place, but the excavation at Mr. Beadle's wharf is of recent date. He agrees with that part of Mr. Beadle's evidence which relates to this silting up, and that he has always found it necessary to keep one man to look after it, but the cause of it is, that foreshore low water line has gone out at Erith causeway an enormous distance within the last few years, and the increasing deposit of mud is exactly what must take place on account of the slack water. Below Erith Pier the foreshore has not gone out an inch since 1833, comparing it with the chart, but it will continue to go out above the Pier, to what distance he cannot say, 13,386–8. He is not aware that, in a report upon the drainage system in 1857, it was stated that Erith Reach would not be a fit place to receive the sewage because it would silt up, 13,389. He knows for a fact that the accumulation of mud near the Club causeway is not largely composed of sewage, and the statement of the man in charge of the club-house, that it is composed of "that which comes from the human frame," is absurd. The man is strong and healthy, and his children are always playing about in the mud. He does not know that any of those children have had any illness, but he knows the man well and has often landed at the Club causeway, 13,390–3. No one speaking truly could say there was sewage in Erith Bight, and speaking ordinarily, it will not smell of sewage, 13,394–5. The samples of mud which he took for the former inquiry were all analysed by chemists, 13,396–7. The tide flowing down does not come into Erith Bight, but as it flows up, he has no doubt it would come into the Bight, 13,406–10. Mr. Law will, when examined, produce comparative sections of the river for different years, showing how much the bed of the river has been dredged of late years, which the Metropolitan Board of Works contends has caused this advance in the low water line, and they deny that it is caused by the deposit of sewage, 13,411–13.

Injury to Fish.—In the summer time the fish are taken out of the wells of the fishing boats at Gravesend. They are conscious of the effect of the sewage, not of the sewage itself. In the winter time he has seen the Dutch eel boats passing through the water by the outfalls, 13,033–5. He has frequently seen people catching fish at Gravesend, and he has watched the fish being brought up in wells through Long Reach and past the outfalls on the 7th August 1882. They did not seem at all uncomfortable, and the captain of the boat told him it was the usual thing, 13,059–286. He does not remember that year being very wet, 13,287.

Effect upon Health in the Neighbourhood of the Main Outfalls.—He never noticed any offensiveness during the hot weather in 1877, nor did he hear any complaint from the men who were working in Long Reach at that time, and there were between 200 and 300 men employed. They used to bathe in the river in hot weather. It was not possible for anyone on the banks to tell either by eye or by nose whether there was any sewage being discharged from the main outfalls or not, 12,978.

Set of the Tide.—Generally if a float be put into the river opposite Barking outfall at high water, it will move at first very slowly until opposite Barking Creek. It will then begin to be deflected towards mid-channel; 1,000 yards below the outfall it will be in mid-channel, and will then set over close to Leatherbottle Point. Having turned the point, it will move parallel to the Crossness Quay wall until nearly opposite the Belvidere Guano

## Mr. GEORGE CHATTERTON—*continued.*

### Set of the Tide—*continued.*

Works, when it will set over to the Essex shore, and pass close to Cold Harbour Point; it will then pass down the centre of Erith Rands to about opposite Messrs. Easton and Anderson's works. If a float be put into the water two hours after high water, it will take the same course to Leatherbottle Point, but then it will cross over to the deep water upon the north side, and pass close to Dagenham jetty, and so along the north side of Halfway Reach and Erith Reach following the course as described already, 13,078–81. The sewage discharged at Crossness follows a parallel course to the river wall, until it reaches Jenningtree point, when it is deflected to the Essex side, and goes down the northern side, passing close to Cold Harbour Point in deep water. Erith being in a bight, the sewage never passes straight into the bight, but keeps the opposite side when discharged either at Barking or Crossness. He has made many observations, but has never seen a float go into Erith Bight at that time of the tide, 13,082–4. When making float experiments for the purposes of this inquiry later in the year 1882, a float traversed Erith Bight. His notes and observations of these experiments he did not keep he regrets to say, 13288–309.

## Mr. THEODORE MAXWELL, M.D., F.R.C.S. Edin. B. Sc., San. Sc. Cert. Camb.

Fellow of the Chemical Society.

Effect upon Health in the Neighbourhood of the Main Outfalls.—He has lived at Woolwich for five years, and his practice extends all over Woolwich and Plumstead. He holds a Cambridge University Sanitary Science Certificate, 13,414–9. His patients include all classes of people, 13,421–2. He has seen very little typhoid fever in the district, and he cannot conceive of its being particularly prevalent unknown to him. Personally he has had three cases in five years, and he knows of one or two cases which have been attended by other medical men in the locality, 13,423–8. He has seen one undoubted case of diphtheria in his own practice at Shooters Hill a few weeks ago, and one doubtful case; two other cases in the lower part of the town he saw when in consultation. He knows of no other cases, 13,429–30. Scarlet fever and other diseases of that sort he does not believe to be peculiarly prevalent, but they are not less prevalent than elsewhere, 13,431. He knows from personal experience, that the river smells badly, but he is unable to trace the diseases to the presence of sewage in the river, 13,432–3, 13,438–44. He traced one case of typhoid fever to defective sanitary arrangements in the patient's office in London, and the two other cases were due to the defective closet arrangements at the Becton Gasworks, where the men (father and son) worked. The cases were almost simultaneous, 13,434–6. The general health of the people of Woolwich is very fair; it is, as far as his practice enables him to judge, as healthy as most places, and he has never had any reason to believe that the river exercises any injurious effect upon the health of the district, though he has smelt it often enough. He has crossed the river frequently, but has no recollection of the smell being very bad in 1882, 13,437–40, 13,457. He lives on the common, a mile from the river, and has noticed the smells from the factories there, but never any smell from the river. He attributes the smell of the river to sewage, 13,441–50. The two cases of typhoid from Beckton Gasworks occurred in the winter, 13,451–2. Many poor people do not call in medical aid unless the illness is serious. For measles and diarrhœa a doctor is seldom called in, except in the case of clubs, when a doctor can be called in for nothing, and he is medical attendant to several; but there are not many scarlet fever cases unattended, 13,453–5. He would not like to express an opinion as to whether the injurious effect of the river would show itself principally in scarlet fever, measles, and diarrhœa, as Professor Corfield stated in his evidence, 13,456. He has had no illness himself from this smell, but many patients have had nausea and headaches, which they and he attributed to the smells from the factories. He never heard, nor have they complained, that it was due to the smell from the river, 13,460–1. He practised for a year and a half before he came to Woolwich, and he had one case of typhoid fever there. There was a considerable epidemic of typhoid at Hanwell before he practised there. Before going to Hanwell, he was in India, 13,458–9.

## Mr. WILLIAM WARMAN COLEMAN, M.R.C.S.

District Surgeon under the Factories and Workshops Act, 1878.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—On the night of the "Princess Alice" disaster, he was rowing about in a small boat examining all the people who were picked up, and on the next day he was on board the "Heron" steamer picking up the bodies, which were placed on board preparatory to being taken ashore. They were not particularly muddy, nor had they the appearance of sewage about them, 13,485–90. He has seen many cases of drowning, and bodies taken out of the Thames, are always more or less in a muddy condition, 13,491–2. Prior to his attention being called to this inquiry, he had never noticed the smell from the river, and since then he has tried to detect it by crossing the river at low water, but was surprised to find how little smell there really was, 13,493–4, 13,497–8. At times the smell from the factories in the neighbourhood is frightful, particularly at night when the wind is in the east or north-east, 13,495–6. He read in the daily papers accounts of what was being done in connexion with this Commission, and saw boats floating about with people taking samples of the water for examination. It is about two months since he was asked to give evidence on the subject He expected to find the river in a much more offensive state, 13,498–502, 13,531–3. He has sometimes noticed a very slight smell from the mud on the banks, but more frequently he has never noticed it, 13,503–4. In comparing the state of the bodies of the people drowned in the "Princess Alice" with others, they were mostly the bodies of people who had fallen into the river from vessels, or drowned while bathing, close to the Arsenal. He has not observed the condition of bodies taken from other parts of the river, 13,534–6. From the fact that those drowned in the "Princess Alice" disaster were in good health and in full habit of body, decomposition would set in more readily than it would in ordinary cases of death; the weather was warm at the time (September) which would assist decomposition, especially in the case of obese persons. After being submerged for two days, the latter would be in a very offensive condition. The bodies of those he saw were not black, but the faces were all turgid and bloated, as is invariably the case where animation is suspended suddenly, 13,537–9. He goes to the marshes frequently to see people who have moved in the direction of Erith from Plumstead, they having been old patients of his, 13,540.

Effect upon Health in the Neighbourhood of the Main Outfalls.—He has lived for 26 years in Plumstead Road, Woolwich, which is about 200 to 300 yards from the river, and has practised as a medical man for the whole of that time. For five or six years he has attended the Arsenal, and as surgeon under the Factories and Workshops Act, he has constantly to visit the factories, &c., in the district, 13,462–9. Neither he, nor any of his family, have experienced any ill effects from living close to the river, 13,465. He visits a great number of people living on the river banks, and also the families of working men, and zymotic diseases are not prevalent amongst his patients, 13,470–2. Considering the enormous population, Woolwich (and Plumstead, which is a part of Woolwich) is a very healthy town. He has no statistics as to the death-rate, as there is no medical officer for Woolwich, 13,473–4. Part of Woolwich stands high, on gravel and sandy soil, and as regards zymotic diseases the lower part compares favourably with the higher. The greatest number of zymotic diseases have occurred at a place called the Slades, across Plumstead Common, which is the part most remote from the river. Whether due to defective drainage or not he cannot say, 13,475–6, 13,481. He has never known a case of zymotic disease produced by sewage in water, except when the mixture has been drunk. There were eight deaths amongst his patients in 1882, but none of these were due to zymotic diseases or blood poisoning, 13,477–9. The drainage of Plumstead Marshes has produced a very beneficial effect on the health of the people in the neighbourhood, 13,480. He has seen "mud-larks" playing in the mud near the Arsenal, and boys are constantly bathing there. Except from immersion and suspended animation when a boy has gone beyond his depth, no evil results have arisen, 13,482–4. Where sewage is poured in large quantities into a river, a deposit is formed upon the banks, which, when exposed to the sun, gives off poisonous emanations to the air, and so typhoid fever and scarlet fever may

## Mr. WILLIAM WARMAN COLEMAN—*continued.*

Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

be communicated to other places, and so to people living on the banks. Against that statement, however, he mentions the case of a man who, with his family, has lived for 19 years at No. 1, Land Magazine, without any disease occurring. Zymotic diseases have been conveyed by sewer gas, and the germs of the disease are carried by means of the air, but he would not like to say that the same would apply to emanations from river banks under a hot sun. He believes it to be a moot point between the highest authorities, 13,505–19. He has not seen the Report of Messrs. Bidder, Hawkesley, and Bazalgette, upon this subject, and would, therefore, rather not express any opinion upon their statement, "the condition of the stagnant mud is injurious to health." He did not know until yesterday that he was to give evidence, and consequently has not prepared himself in any way, 13,520–2. He has not compared the death-rate in the parishes by the banks of the river with those not affected by the river, nor has he ascertained whether diarrhœa, measles, and typhoid fever are more frequent in the riverside parishes than in others, 13,514–5. A thing may be injurious to health without creating zymotic disease. There is a difference in the condition where gas is given off from a sewer, or where gas or vapour is given off from the banks into the open air, and so is diffused into an immense bulk of air, 13,523–6.

## Mr. F. LETT, M.R.C.S., L.R.C.P. Edin., &c.

District Medical Officer to the Woolwich Union.

Effect upon Health in the Neighbourhood of the Main Outfalls.—He has lived for 11 years at Rectory Place, Woolwich, which is about a quarter of a mile from the river, and his practice is near the centre of the town. His district extends from the river nearly to the top of Woolwich Common, and he has many patients amongst the labouring classes employed on the river, and living both near, and on the banks of the river, 13,541–9. He has had no cases distinctly traceable to the presence of sewage in the river, and the general ratio of zymotic disease in his practice, as compared with the ratio of zymotic disease to other diseases in the country is comparatively low, 13,550–1. He has had cases of typhoid fever, diphtheria, diarrhœa, and scarlet fever, but he could not trace them to riverside occupations, 13,552–7. He has had opportunities of judging the sanitary condition of the river, but he has never been able to trace any deleterious effect upon the health of the inhabitants arising from it. In his opinion the general health is very fairly good, 13,558–60. He has smelt the sewage in the river in hot weather, but is uncertain whether he noticed it in 1882. He cannot trace any disease arising from the deposit upon the banks of the river, whether zymotic or otherwise. He would not like to say whether sewage in water (not drains) could create zymotic disease, 13,561–5. The smells from the factories are very disagreeable and offensive, but he would not like to say that they were productive of disease, 13,566–8. He has had no complaints from people suffering from nausea or diarrhœa arising from some unexplained cause which would cause special remark on his part, but the smell from the river, which he has noticed, would be very unpleasant to persons already in ill-health, and might be to a certain extent injurious, or of a prejudical character. He has, however, no knowledge of any such cases either in his own district or elsewhere, 13,569–71, 13,585–9. He has never been able to distinguish whether the district away from the river is more healthy than that part nearest to the river. Had such a difference existed, he would have noticed it, 13,572–4. There has been no prevalence of diseases near the river which have their origin in bad air and water in his district, 13,575. Most of the cases of typhoid fever, diarrhœa, and measles in his district have remained untraced, 13,576–7. The people living on the river banks are, as a rule, poorer than those further away, and receive medical attendance gratuitously. In cases of any diminution in *vis vitæ*, referred to by the Vicar of St. Nicholas, Plumstead, they would in all probability call in the medical officer of the union, as he can order them, besides medicine, other things much desired by the poor, such as aliment, 13,578–84.

## Dr. ALFRED ROWARTH.

Medical Officer to the Training Ship "Exmouth."

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—The "Exmouth" is stationed off Grays, at which place he lives, and goes on board every day except Sunday. He therefore has opportunities of judging of the state of the river, 13,590–4. He has never seen any traces of sewage in the river, nor observed any smell from the water. He has never noticed any smell of sewage on the banks, the only smell being that of mud banks in general, 13,595–8, 13,611–15. In the summer months a bath on board the "Exmouth" is filled with river water in which the boys bathe daily, and he also has bathed in it, which he would not do if he thought there was sewage in the river at that point, 13,599–602. There is nothing perceptible in the state of the water to lead him to suppose that sewage was discharged higher up the river, 13,603. He has been connected with the "Goliath" and "Exmouth" for 11 years, and there are between 500 and 600 boys on board the "Exmouth," 13,606–7. The smell from the mud is an earthy smell, and is totally different from a sewage smell. He could detect the difference immediately. The smell from the mud is not unpleasant, 13,614–5. The "Arethusa" is moored off Greenhithe, and the "Cornwall" is stationed off Purfleet. The smell of the mud is very bad there (at Purfleet), but he does not know anything about Greenhithe. The river is not so clear at Purfleet as it is at Grays, 13,616–21. There is no bathing at Gravesend now, because there is no convenience for it. He has bathed at Grays upon the lowest ebb tide, but prefers the top of the flood, because the water is salter and clearer, 13,622–8. The health of the boys on board the "Exmouth" is very good indeed, and fever and diarrhœa are distinguished by their absence. Boys are received on board from 11 years to 15 years, and there are between 500 and 600 of them on the ship. When admitted first they are not healthy boys, 13,604–10.

## Mr. HENRY LAW, M. Inst., C.E.

Member of the Council of the Sanitary Institute of Great Britain, and Fellow of the Meteorological Society.

His first acquaintance with the Thames, commenced in 1837, when he was articled to Sir Isambard Brunel, who was then constructing the Thames Tunnel. The nature of that work rendered it necessary that the should make himself acquainted with the movements of the tide and the conditions of the river-bed, and he had to watch the tides carefully and make daily observations on the river, 13,629–33. He subsequently became chief assistant to the late Mr. Thomas Page, and he made the working drawings for Mr. Page for Westminster Bridge. In 1843 or 1844 he prepared plans for the Thames Embankment, and took soundings and made 61 sections of the river to compare with those taken by Mr. Telford in 1823 to see what change had been occasioned by the removal of London Bridge, 13,634–40. He has also prepared plans for the construction of Charing Cross and Lambeth Bridges, and superintended the building of the Victoria and Albert Bridges over the Thames at Windsor. He has, therefore, acquired an intimate knowledge of the Thames, 13,641–2.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He begins by quoting an extract from page 11 of the paper laid before the Chemical Society on River Water, by Dr. Tidy, and its capability of purifying the sewage discharged into it. He has made a calculation to enable him to tell what proportion of pure water there would be to receive the sewage poured into it at the outfalls. He produces a diagram (*see Appendix B. O.*), upon which the heights are plotted to the tenth of every tide, and he finds that the quantity of water coming ever Teddington Weir on the 3rd October 1882 between high and low-water was 61,900,000 cubic feet. The quantity of water in the river flowing out between high-water and low-water at Crossness was 2,523,000,000 cubic feet, which gives a total of 2,585,000,000 cubic feet passing between Barking and Crossness on that tide. The sewage discharged in one tide is 9,894,000 cubic feet; and that bears a ratio of 1 to 261 as compared with river water, which is 13 times the quantity Dr. Tidy considered necessary to purify the sewage, except that it must be borne in mind that the water, Dr. Tidy said, was already contaminated

## Mr. HENRY LAW—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

with sewage, 13,855–61, 15,157–65. Unless, therefore, the river contains the unaltered sewage of 12 tides, that volume of water would be competent to purify the sewage, 13,862–3, 15,157–65. On the 14th September, when it is stated that the water in the river was more impure than on the other days when the samples were taken, he finds that the water at North Woolwich was nearly as pure as the drinking water supplied to the inhabitants of London, and, therefore, capable of purifying the sewage which was delivered to it in the proportion of $\frac{1}{260}$th part of its bulk. At low-water on that day, the water in the river at North Woolwich might have been drunk with impunity and without disgust. It was a day or two after spring tides, when the overflow is greater than the inflow, and the sewage does not come back so high up the river when the tides are taking off, 13,863–74. 15,114–25. With reference to Professor Way's statement (Q. 12,289) that 100 tons of oxygen were required to oxidise the sewage, and if it were possible that the whole of the sewage should be burnt up day by day as it went in, the air of the neighbourhood would be irrespirable, the stock of oxygen being exhausted. Now he has made a calculation to test that statement. The sewage he admits travels about 12 miles down and 11 miles up the river as a rule, and the mean superficial area of the river for 12 miles below Barking is 151,000,000 square feet, and each cubic foot of air contains 123 grains of oxygen, so that a layer of air only one foot thick would contain 1,189 tons of oxygen. So for the 11 miles back there would, at the same rate, be 1,093 tons of oxygen, making 2,282 tons of oxygen, or 46 times the quantity required. If the sewage did not take up the oxygen for more than a foot, it would not affect the atmosphere in the neighbourhood. That shows how dangerous a thing it is to make random statements without making a calculation, 13,875–6. The cubic foot of air above the surface he uses as an illustration only, not as a fixed quantity, 13,879. Again, water contains two cubic inches of oxygen to the gallon, and will not absorb more. But if any of that quantity be extracted the water sucks it in from the air with avidity. From the tables of analysis the water is shown to contain an inch of oxygen on the average at the outfalls (and an inch weighs ·3438 of a grain), it contains, therefore, 354 tons of oxygen, which is seven times the quantity required before it has to take any from the atmosphere; and, as at Erith, the water is found to contain ·42 of an inch, the inference is that the balance has been used in burning up the sewage. It is the exhaustion of the oxygen in the water that kills the fish in the river, 13,877–8. A good deal has been said about the pure state of the water many years ago as compared with its present condition. When he was engaged in constructing the Thames Tunnel, serious inconvenience was caused by the character of the ground which came from the bed of the river into the excavations, poisonous gases and inflammable gases came into the shield and caught fire, burning for a considerable time, and the health of the men was affected by these emanations, 13,959–60. In 1839, before all the sewage was turned into the river, the houses were drained into cesspools, and it was an offence at common law to carry the overflow from a cesspool into the sewer, and it was not until Bramah invented the watercloset that the connexions were made surreptiously, and at last they were made so extensively that the law was altered, and from being prohibitive, it was made compulsory, 13,961, 15,175–80. A lengthy description of the state of the river will be found in the First Report of the Thames Conservators issued in 1858, and in Mr. Farday's letter to the Lord Mayor in the same year complaint is made of the condition of river. He also calls attention to the joint Report, dated 15th April 1878, of Sir J. Bazalgette, and Messrs. Law and Chatterton, 13,962. If he had the power, he would not take the sewage 20 miles further down the river, but if he could do it for nothing, he would not hesitate to discharge it into the sea as he has always advocated that measure. It is no nuisance where it is, because he believes that, if people were ignorant of the fact that the sewage was discharged into the Thames, no person passing up and down the river would ever find it out unless they went within 100 yards of the outfall itself, 13,966–73. While the sewage is not practically appreciable, there exist intolerable stenches from the factories, and from barges with putrid bones. He has seen clouds of smoke and

steam, within the last six months, proceed from the works of Messrs. Odam at Bow Creek which obscured half the river, and the smell from the salicylic acid was intolerable. The stench from the bone barges is so nauseous that it is impossible to conceive anything more offensive. These are nuisances, but he really considers the nuisance of the sewage inappreciable, 13,973.

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THN MAIN OUTFALLS.—He has given some attention to the subject of deposits in the river, and the Thames must be a muddy river, for no river under the conditions of the Thames can be otherwise than muddy. The traffic is so large, and the water is kept in such continued agitation, that it is impossible for the mud to settle, 13,880–2. Dr. Frankland put in a report with copious tables, which showed that upwards of 1,000,000 tons of solid suspended matter were discharged into river from the outfalls every year. Now Table B, which deals with this question, contains several errors, and these inaccuracies affect the average. In one case the rain falling was described as "very slight "rain, not measurable," whereas on inquiry he found the amount of rain fall was $\frac{1.5}{100}$ths in 18 hours, or nearly the maximum amount that provision was made for in the sewers. Again, he cannot find in Messrs. Hoffman and Wilt's Report any statement that there are 209 grains of solid matter in each gallon discharged, as quoted by Dr. Frankland. The value of these tables is destroyed, owing to the fact that when these observations were taken in 1857, the system of sewers was totally different to that now in existence, 13,882–6. He further disputes Dr. Frankland's statement that $\frac{1}{100}$th of an inch of rain in 24 hours would increase the flow of sewage at Barking by 14,000,000 gallons, and the proportion of solid deposit in every gallon would be increased from 23 to 42·9. Now not a drop of such a rainfall would ever reach the sewers, 13,887–90, 15,126–8. Mr. H. Leach, when before the Mud Inquiry Commission, stated that the whole of the mud in the river came from the sewers. Now he contends that the mud washed from the banks and the saltings by the wash caused by the passage of large steamers, which are yearly increasing in size, speed, and number, up and down the river, contributes principally to the muddy state of the river, and also that this said mud contains matter in it as noxious as the mud found at the bottom of the river. Another thing that helps to wash away the banks is, the increase of two feet in the height of the tide since the removal of old London Bridge, 13,890–902. The banks in the higher reaches of the Thames are being destroyed also by the steam launches, and the reports of Colonel Bolton show how large a quantity of detritus is washed over Teddington Weir, 13,902–6. If the sewage were shut out of the river altogether, there would be no tangible difference in the quantity of mud deposited on the mud banks. He produces Plan No. 19 of a large salting in the river at Broadness (*see* Appendix A.E.) to show the manner in which the saltings break down. The total length of river bank from Kingston to All Hallow's and Teddington to Yantlet is 133 miles, 43 miles of which in 1879 were unprotected, 13,907–8. He hands in Diagram No. 34 (*see* Appendix B. M.), which is plotted from observations taken jointly by Mr. Keats and Dr. Tidy for a month to ascertain the quantity of water flowing over Teddington Weir, and of the quantity of suspended matter in that water. On the 7th February when there was no rain, the amount of suspended matter was only ·18 in a gallon, and only five or six tons came over altogether. On the 21st February, in a time of rain, the quantity of water increased by six times, the suspended matter was 24 grains, and the total quantity of suspended matter was 4,666 tons. The table is contained in the Mud Inquiry Report, 13,909–11. His next proposition is that in a river so laden with mud, if there is slack water, mud must be deposited there. He produces sections of the river taken in 1796, in 1823, and in 1843, in which the places where the water has deepened is coloured blue, and where shoaling has taken place, the sections are coloured red. Above London Bridge it is all blue, while below all the sections are red down to Blackwall Point, which is as far as he has taken these sections, 13,911–20. He hands in Diagram No. 18 (*see* Appendix B. L.) and Diagram No. 35 (*see* Appendix A. Z.), 13,921–22. Many of the changes and banks have arisen to a great extent from the system of artificial dredging which has been carried on since the appointment of the Conservators in 1858. Prior to that, the Trinity Corporation dredged for ballast only, but the Conservators have used extremely powerful dredging machines, and have even resorted to the use of gunpowder to break up iron bound gravels which formed shoals or shelves. A great improvement in the navigation of the river was no doubt effected, but the result has been to increase the section of the river and to diminish the velocity, causing a deposit. He hands in Diagram No. 6 (*see* Appendix B. A.), and Diagrams Nos. 7 to 13 (*see* Appendices B. B., 1 to 7), showing the commencement of the formation of the shoals in the neighbourhood of the outfalls prior to the outfalls being put there. An examination of these sections will show that where dredging was, deposit takes place, and that the deposit was the nucleus of the banks of which complaint is made. He hands in Table 9, giving a comparison of the velocities of the ebb stream at half-ebb of an average tide in 1861 and in 1864, in feet per minute, 13,923–6. He hands in Plan No. 5 (*see* Appendix B. C.), showing by brown spots where mud was shown to exist in 1861 by the Conservators in Erith Reach and Erith Rands, 13,926–7. He hands in four coloured plans showing the form and depth of the channel in the same part of the river from soundings taken in the years 1831, 1861, 1879, and 1882. He hands in (*see* Appendix B. E.) a table No. 10, which is a resumé of the contents of Plan No. 20 on a small scale, showing the low water capacity of Divisions 2, 3, and 4 of the Thames derived from soundings in the above mentioned four years, and giving the percentage of increase of the total contents of the channel, 13,927–30, 15,129–56. He hands in Diagram No. 21 (*see* Appendix B. F.), which is a longitudinal section of the river from Teddington to Gravesend, showing by means of blue lines the surface of the water half an hour before the middle of the ebb, and half an hour after middle ebb. By this means, the quantity of water passing any point during the middle hour of the ebb tide can be accurately ascertained, and having the transverse sectional area, the velocity can also be ascertained. He hands in Table No. 11, showing the mean velocities of the current in the river Thames between Blackwall Point and Long Reach during the middle of the ebb tide on the 3rd October 1882. It is compiled from sections plotted by Mr. Shelford, Mr. Mansergh, the Metropolitan Board of Works, the Thames Conservators, and Messrs. Law and Chatterton in the years 1877, 1878, and 1879, 13,930. Diagram No. 17 (*see* Appendix B. G.) shows the lines of the respective sections; the horizontal line A. A. is put at an altitude above the datum line which represents a mean velocity of 196 feet per minute, or 2¼ miles an hour, as about that which would keep the river clean. The parts coloured pink show where the velocity is too slow, and the blue parts where the velocity is high. If the velocities rise and fall and they are assisted by the river being tortuous and of varying width, deposit is inevitable, and is the natural result, and is not the result of accidental proximity of those places to the sewage outfalls, which are quite inadequate to produce the result even of those shoals alone. Diagram No. 14 (*see* Appendix B. H. (1,)) shows the low-water sectional areas between Jenningtree Point and Dartford Creek in 1833 and 1861, and it will be seen that the sectional area has increased exactly where the mudbanks are complained of. Diagram No. 15 (*see* Appendix B. H. (2.)) gives similar details for 1861 and 1879. Diagram No. 16 (*see* Appendix B. H. (3.)), on being compared with the previous diagram, shows that the places where the sectional area is diminished, as shown by the brown spots, are just the same as the spots where it had been made abnormally large, 13,930, 15,129–56. In midstream off Erith Pier, there is a very large mudbank, which has been deposited by the water on the south side. No doubt the water had its due admixture of sewage, and contributed its share to the bank as adding to the solid matter to the river, but he will not admit that the banks are partly formed of sewage. Some part has been contributed by the outfalls, but it is not right to assume that that is sewage because it came out of the outfalls. Sewage may be divided into two parts, the perishable and that which is permanent, and it is the latter only which contributes to the banks. The ratio of the sewage to other matters is so small, that the effect is inappreciable. If there had been no sewage in the river there would still have been a deposit of mud in the bed of the river, 13,935–47. On

Mr. HENRY LAW—*continued.*

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

the 30th April 1839, when constructing the Thames Tunnel, a considerable rush of ground took place, bringing with it every description of river deposit and dirt, a root resembling a seaweed in a fresh state, oyster shells, &c., accompanied by a very strong effluvia. The stench in clearing out the frames was horrid, the ground thus removed was black mud, river deposits, small coals, and masses of black clay. That was the nature of the bed of the river in those days before the sewage was turned into it, 13,960–1. In 1872 he went down the river accompanied by the Commissioners on the mud inquiry, and dredged up mud wherever they pleased, including the bank opposite Crossness, which it is alleged consists entirely of sewage. The whole of the mud so brought up was of a perfectly inoffensive nature, and not a single sample of offensive mud could be found, 13.962. When the Dagenham shoals were removed the river was larger in its section in Halfway Beach than the cross section below was originally, and on Mr. Mansergh's section made in 1878, the accumulation of mud is shown with a consequent constriction of the river at this point. He does not know that in 1882 it had become still smaller, and although so shown on Mr. Mansergh's diagram of 1878, he cannot say that it is not correct. He does not think that section could have been taken before the shoal was removed. Assuming that it becomes smaller, it does not follow that that deposit must be of such a character that if the floods should sweep it away it would re-deposit in the ordinary currents, because where the largest accumulation has taken place, the velocity of the current is even now far to weak. Although there are one or two points where there is a stronger current for a short distance, it is not sufficient to affect the deposit upon the south side, 15,129–42. The cross-sectional area of the river before the Dagenham shoal was removed at half ebb was about 40,927 square feet, and the actual area now is between 56,000 and 58,000 square feet, as will be seen on reference to Diagram 10. He will furnish the exact area, 15,143–56. He has not gone into the chemical composition of the mud at Erith. It has no smell at all except of earth, even on warm days, unless it is stuff taken out of the sewers which trickles over the surface, 15,173–4. Since the last meeting of the Commission, he went down the river and took samples of the mud at those places where it had been described as being "derived from the human frame." Although the weather had been dry and warm for some time, there was no smell in it whatever, except the ordinary smell of mud. The samples were taken at low-water, 15,187–92. He is now able to give the area of the Crossness section on the line D. D, asked for (*see* Q. 15,143–6). In 1833 the sectional area at low-water was then 20,445 square feet; in 1861 it had been enlarged to 33,780 square feet; in 1864 it had diminished to 28,770 square feet; and in 1879 it had been increased to 33,850 square feet, 15,703–4.

Effect on Wells near the River.—He calls attention to Mr. Latham's statement that the discharge of sewage into the river is likely to affect the wells in the neighbourhood (Q. 7944), and he wishes to point out that the water which exists in the chalk stands at a very high level of 400 feet at a distance of some miles from the river, and falls with a gradual gradient towards the river, from which it is plain that the water will run from the wells into the river, and not from the river into the wells. If there are any wells where the water stands at a lower level than the high water in the Thames, it proves that some impervious stratum of clay exists between the well and the river, thus cutting off access to it, otherwise the river water would reach its level in the wells. The cause of the rise and fall of water in the wells with the tide is due to the increased pressure of the tide, which prevents the chalk water escaping, and so fills up the wells, 13,962–5.

Distribution of the Sewage in the River by the Various Motions of the Water.—In the Thames water there are four elements, viz., the upland or surface water draining into the river; the spring water, which finds its way into the bed of the river through the springs; sea-water; and sewage. The spring water up to the present time has been ignored in considering the question of dilution of the sewage, 13,720. In considering this part of the question, it is necessary to ascertain what it is reasonable the river should deliver, comparing the upper and the lower. He therefore

Mr. HENRY LAW—*continued.*

Distribution of the Sewage in the River by the Various Motions of the Water—*continued.*

ascertained first the quantity of water abstracted by the water companies. The water abstracted above Teddington amounts to 7,778 cubic feet a minute, which must be added to the quantity gauged by Mr. Latham as coming over Teddington Weir if it had not been abstracted. The East London Water Company abstracts 2,444 cubic feet per minute from the Lea, and the New River Company takes 5,868 cubic feet per minute from the underground springs at Amwell, making a total of 16,090 cubic feet per minute for the water supply. The mean discharge over Teddington Weir from the 7th September to the 30th November was 338,488 cubic feet per minute, which, with the 7,778 cubic feet, gives a total of 346,266 cubic feet per minute draining from the 3,676 square miles of country above Teddington, or 94·2 cubic feet per minute per square mile. Below Teddington the mean discharge is 61,709 cubic feet per minute, and, adding 5,868 cubic feet, gives a total of 70,021 cubic feet per minute for the 1,486 square miles below Teddington, or 47 cubic feet per minute per square mile. From this it will be seen that the quantity of water delivered from each square mile above Teddington is double the quantity from each square mile below Teddington, 13,726–30. This agrees with Mr. Latham's statement. Now, in Mr. Symon's tables of rainfall (in which he has corrected a few slight inaccuracies) the quantity of rain which fell during three months in the upper basin of the Thames amounted to 13 inches, and in the lower to 11¼ inches. To arrive at a reasonable result, these relative rainfalls must be discounted, for, assuming the geological conditions to be the same, and supposing the surface of the ground were of a similar character and would allow all the rain to run off, then the quantity of flow which would be gained at Teddington would bear to that which would be obtained in the Lower Thames the proportion that the rainfall bore in the one to the other. That being so, 121,230 cubic feet a minute should be delivered below Teddington instead of 70,000 cubic feet a minute as gauged by Mr. Latham, the excess of 51,209 cubic feet being due to geological conditions and the character of the country, &c., 13,731–40. Now, the reason of this difference between the quantity of water coming over Teddington and the quantity below as gauged by Mr. Latham is due to the very large quantity of water which finds its way into the Lower Thames through its bed by springs, and it makes a very important difference indeed in the ratio of the upland water to the lower. On the Ordnance map which he hands in (*see* Appendix, B. P.), he has coloured the outcrop of the gault, which upon the line coloured blue is from 200 to 800 feet higher than the level of high water. In Kent it is sufficiently high to form a basin, and descends to a depth of 600 feet below the sea level, and it is perfectly impervious to water. The chalk and gault run beyond the Thames Valley towards the sea, but owing to the incline of the strata, the water falling on the chalk finds its outlet in the valley of the Thames. The whole surface of the chalk is singularly free from rivers, but numerous "swallow-holes," as they are called, exist, absorbing enormous quantities of water, the 5.868 cubic feet per minute pumped up by the New River Company being only a portion of that water, 13,741–4, 15,182–6. Immediately above the gault and forming the green line is the upper green sand; the pink portion of the plan is the outcrop of the tertiary beds which are pervious to water, and the grey is the London clay, which is impervious; so there is an enormous reservoir of water imprisoned between the London clay and the gault; this tends to prove that there is a large quantity unseen of water which enters the Lower Thames and which has not been estimated, 13,744–51, 15,182–6. He hands in sections, Nos. 27 and 28 (*see Appendices, A. S.* 1 and 2), which were taken more or less at right angles to the course of the river through the Thames Valley Section. No. 27 is from observations taken a year ago by him for another purpose. The names of the places where wells extending to the chalk were dipped at intervals show the level of the water, and it will be seen that at Tring the water stands at 453 feet above the Thames, and then falls gradually until at Isleworth it is at the level of the Thames. It is always being supplied from above, and it is always escaping either into the bed of the river or the sea, 13,751–2, 13,757–62, 15,044–6, 15,182–6, 15,194. The total area of the Thames basin is 5,162 square miles, of which he lower tertiaries, the chalk, and the upper green sand

MR. HENRY LAW—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

(all of which are pervious and admit the rain) contain upwards of 4,000 square miles of country, and which absorbs a large proportion of the rain which falls upon it. In many parts, where either the gault or London clay meet the chalk, the rivers which had been formed upon less pervious strata disappear, being absorbed by the chalk. These "swallow" or "swilly" holes exist to a large extent in the River Mole between Dorking and Leatherhead, and they also exist at Canterbury. Farnham, Newbury, and Hungerford; and also in the valley of the Lea between Barnet and Hatfield there are a series of streams or rivers which have no outlets whatever, but disappear, and are the feeders of the Amwell Springs. He has coloured these on the map as they exist (*see* Appendix B. Q.). They have no outfall whatever into any river, and so could not have been gauged by Mr. Baldwin Latham. They come to an end at South Mimms and Mimms, 13,752–6, 15,033–73, 15,077–82, 15,194. Full particulars of the geological formation of the Thames basin, the swallow holes, and the escape of the rain and surface-water into the Thames and the sea are to be found in Mr. Prestwich's paper, volume 10, (in the Proceedings of the Geological Society, page 222; in Mr. Long's paper, volume 3, page 101; and in Mr. Clutterbuck's paper in the Journal of Royal Agricultural Society, volume 25, page 306, 13,757–63. He wishes to call attention to the fact, which is important, that the water-levels during the whole of the year in section 27 varied from ·58 of a foot near the Thames to 18·9 feet near Tring. The water in the chalk varied with the season, with the rainfall below that height, so that the hydrostatic head was a little greater at some times of the year than at others. In Mr. Barlow's paper, read at the Institution of Civil Engineers in December 1854, it was suggested that the large quantity of water running through the chalk into the Thames should be intercepted for the supply of water to London, and mention is made therein of the visible springs in the river. These can be seen near Greenhithe at near low water, and he has seen them himself, 13,762–5, 15,192–3. Gault is a very strong clay, almost of the consistency of marl, from which gault bricks are made, 13,766. He hands in a Diagram. No. 29 (*see Appendix A. U.*), which expresses Professor Way's determination of chlorine. The lines express as ordinates the quantity of chlorine, and they become elevated at Erith, instead of being continuous, as they would have been if the chlorine had been a mean quantity, in consequence of the spring water entering there, diluting the sea water and making it more fresh, 13,766, 15,195–6. He points out that Mr. Mansergh has over-estimated the quantity of sewage from some unexplained cause to the extent of nearly 10 per cent. over Mr. Latham's estimate, which is in itself too high, though more exact than Mr. Mansergh's. Mr. Latham took the population and the estimated water delivery at 31·5 gallons per head, which gave, according to his calculation, 16,296 cubic feet a minute. Mr. Mansergh calculated the quantity to be 18,055 cubic feet, whereas he makes it to be 13,742 cubic feet, taking 5 cubic feet, which is equal to 22·5 gallons per day. The difference is an important one. In estimating the quantity of upland water, he finds Mr. Latham and Professor Unwin erroneously stated that the quantity of water passing over Teddington Weir produced an immediate alteration at Crossness, and that the water runs out at the other end as fresh water. This, he contends, is not the case, as it becomes mixed with what is already in the river, and it takes a considerable time to run through. The effect of pouring a large quantity of water into the upper end of a channel of considerable length with water flowing through it is to increase the inclination of the water, and gradually to increase the velocity all the way, 13,766–70, 15,082–6. Now, he says, by taking the quantity of water gauged by Mr. Latham as coming over Teddington Weir upon the 7th September, instead of the 14th September, he gets 144,824 cubic feet per minute instead of 118,000, which makes a considerable difference with regard to the relative volumes of sewage and land water. If from this amount the water supply be deducted, and the deficit of 51,000 cubic feet, which there was between Mr. Latham's gaugings of the Lower Thames as compared with the Upper Thames be added to the amount, it amounts to 193,683 gallons, which has the effect of reducing the per-centage of sewage to upland water, estimated by

MR. HENRY LAW—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

Mr. Mansergh at 15 per cent., to 7·1 per cent., making a difference of cent. per cent. This difference affects a very delicate chemical test which was made at Crossness to ascertain the quantity of sea-water in the river, because by means of chlorine that can be determined. If then they assumed that on the day the test was made the amount of upland water was 118,000 cubic feet instead of 144,000 cubic feet, which came over Teddington Weir a week before, there was so much more left for sewage, which gives an incorrect result, 13,770–95, 15,166–72. He will now deal with the chlorine test itself. The witnesses for the Corporation of London assumed that the sea-water which enters the Thames from the North Sea always contains 1,961 parts of chlorine in 100,000 parts, and if a less quantity of chlorine was found in 100,000 parts in any body of water, the difference is upland water and sewage in the river. This he contends is too high an estimate, because they never found so large quantity, and the North Sea receives all the drainage of fresh water from the east coast of England and also the whole of Western Europe, and consequently the water must be far less saline than the Atlantic Ocean, 13,782–4, 13,795–6. Supposing their assumption was correct, the result would show a much smaller quantity of sea-water than was actually present. His reason for going into this matter is that it is one of the grounds on which the alleged pollution of the river to the degree it is said to be polluted is based. On the 14th September, the whole body of the river was said to contain 11·7 per cent. of sewage, nearly an eighth of the river in fact, which would be a very serious matter, and the quantity of fresh water that comes in as compared with the sewage with which it is mixed can be ascertained with certainty, and that is just where this estimate of the spring water and so forth has such a very important bearing upon this question. His view corroborates his notion of underground supplies, 13,797–804. Professor Way in his Table No. 2, gives an analysis of the sea-water at Margate upon several days, the highest being 1,951, the lowest 1,737, and the mean 1,899. Dr. Frankland gives in his Table No. 3 the mean of the sea-water at Brighton, Penzance, and other places as 1,900, while in mid-Atlantic he gives only 1,800, therefore to attribute any deficiency in the amount of chlorine in the water coming in from the North Sea to the upland water, containing sewage, is an assumption which cannot be borne out, 13,804–5, 15,085–90. He points out that the method of taking the samples of water for chlorine tests does not give a fair representation of the composition of the river, because the quantity of chlorine varies greatly at small intervals of time and within short distances. For example, the depth of the river between Gravesend and Southend, in some places is 80 feet, and to take two samples at 20 feet deep at Erith and two samples at Southend at the same depth cannot give a fair representation of the quantity of chlorine throughout the whole length of that section of 27 miles with sufficient exactness to enable anyone to say positively what is the composition of the water, and to determine that so much is sea-water and so much sewage. Yet that is the proposition that has been laid before the Commission, 13,805, 15,195–6. He has prepared a table which shows the variations which occur in the composition of the water as regards chlorine in very short distances. This Table No. 8 he hands in, and it gives the localities, the date, the state of the tide, the number and position of the sample, the amount of chlorine found, and the per-centage of difference between two samples taken within short distances and at small intervals of time. They vary from 10 per cent. up to 36 per cent. One sample taken at Erith on the 27th July, varied 20·6 per cent. between the surface and the bottom. The variations do not appear to follow any regular rule, but they are very much disturbed by the spring water coming in, and in some places also by the depth, or the set of the tide coming in, 13,805–9, 15,195–6. He hands in Diagram No. 32 (*see Appendix A., X.*) Mr. Mansergh, in Table M., 3 *d.*, (see column 10 added up) shows that on the 30th November at low tide, there were 297,600,583 cubic feet of sewage in the river between Southend and Woolwich, while the total upon the subsequent flood tide, *no sewage having been admitted into the river in the interim*, (column 10 being added up) amounted to 405,683,709 cubic feet, making an increase of 108,073,126 cubic feet, which is equal to the whole sewage of London for 5½ days. These quantities Mr. Mansergh

MR. HENRY LAW—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

obtained by ascertaining the quantity of chlorine in the river. If, therefore, this amount of sewage was actually in the river, it must have been brought back by the sea. It is alleged that there were seven or eight days' sewage in the river at low water, but that at high water there were 12 days' sewage in the river. The river at low water contains about half the quantity it contains at high water, and the proportion the increase in the quantity of sewage bears to the total quantity is 36 per cent., 13,809–29, 13,831–2. He considers Mr. Mansergh's statement is physically impossible. Diagram No. 32. which he has just handed in, shows the way in which the mean of the chlorine was taken. The amount of chlorine at the surface, and at 20 feet below were added together and divided by 2, giving what is called the mean. Now if the water increased in saltness from, say 290 grains at the surface to 338 grains at 20 feet below, they have assumed that the water was as fresh at the bed of the river as it was at the surface, instead of increasing in the ratio that it did between 1 and 20 feet, and when a depth of 80 feet is obtained in a length of 27 miles of river with all its varying circumstances, and trust to an observation at each end to give the quantity of chlorine, he thinks that observations founded upon that slender basis are not sufficiently accurate to draw such very important conclusions from, 13,830. He now comes to the quantity of chlorine in the river water and the sewage mixed. The opposite side have in their estimates taken the river water as containing 1·7 parts of chlorine in 100,000 parts, but the water which enters by springs through the chalk, (especially when it comes from underneath the clay) contains from 30 to 5 parts of chlorine in 100,000 parts. He takes the mean as 10· as against 1·7, so if the water coming over Teddington Weir, which he alleges on the 14th September was 128,734 cubic feet per minute, be taken at 1·7, and the 51,000 cubic feet from the springs at 10, it gives as the mean 4 parts of chlorine in 100,000 instead of 1·7. The chlorine test theoretically is perfectly correct, and given accurate quantities to deal with, which express the mean values, you get an accurate result; but if you apply the principle upon this basis, you will get a very different result, 13,832 The quantity of chlorine in some of these springs of chalk water has been arrived at by actual analysis, and is to be found at page 103 of the Sixth Report of the Rivers Pollution Commission. At Witham, in Essex, which is one of the points of outlet, the chalk water in a well close to its outflow into the Thames has been analysed; Professor Way analysed the water at the South Essex Waterworks, which are close to the point where the water flows into the Thames, and found 13·3 to 13·6 parts of chlorine in 100,000, and at Braintree the quantity is 38·8. It usually contains 15 parts, the mean being 10. The water as it flows into the Thames has never been analysed, but it could be. The other side took their samples from the water flowing over Teddington Weir, which gave 1·7 parts of chlorine, 13,833–45. Pursuing the same calculation as that adopted by Mr. Mansergh in Table M. 3 *b.*, in the division below Crossness, he finds the percentage of sewage in the river on the 14th September is 4·19 instead of 8·9 per cent., which is again about cent. per cent. difference. He points out various discrepancies in the estimates of Mr. Birch and Mr. Mansergh Mr. Birch's average of the whole length of the river being in excess of Mr. Mansergh's estimate by 16¾ per cent., whereas Mr. Birch brought his diagram forward to confirm Mr. Mansergh's. The absolute quantity of upland water and sewage as given by those gentlemen differs from 1½ per cent. less in the third division to 20 per cent. more in the fifth division. The percentage of sewage to upland water varies from 4 per cent to 20¾ per cent. Mr. Mansergh assumes that the quantity of upland water from Erith downwards is always constant, while Mr. Latham makes it increase on the 14th September by nearly 7 per cent. Mr. Mansergh makes the quantity of upland water and sewage in column 9 constant every day for 27 miles of the river below Erith. He makes it the same at Southend as at Erith, the same at high as at low water. Now it is absolutely impossible that the proportion of upland water to sewage should never vary during the 24 hours; that whether at Erith or Southend, whether the sewage has been discharging into the river, or the sluices are shut, the percentage of sewage to upland water should be always the same, is quite impossible, 13,846. He hands in Table No. 8*a* showing the difference between

MR. HENRY LAW—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

Mr. Birch's and Mr. Mansergh's estimates of the sewage in the river below Crossness, to which he referred in his previous evidence. Mr. Mansergh's estimates shows an average excess of 16·74 per cent. on the total quantity over Mr. Birch's estimate. It varies from 8·91 per cent. more in the first division to 44·04 per cent. more in the sixth division. The quantity of upland water as estimated by Mr. Mansergh varies from 1·36 per cent. less in the second division to 20·15 per cent. more than Mr. Birch's estimate in the fifth division; the average being 8·51 per cent. more. The percentage of sewage to upland water and sewage differs from 4·08 per cent. less in the first division to 20·77 per cent. more in the sixth division, 13,249. He now proceeds to make an elaborate calculation with regard to the chlorine tests shown by Mr. Mansergh's Table M. 3 *C.*, the result of which, he says, proves that if the slightest value is to be attached to that table, the upland water in the river was 40 per cent. in excess of the whole quantity of water in the river from Teddington to Southend. Practically the table must be wrong. Another circumstance which would appear to throw some doubt upon the chlorine tests upon the 14th September would be that they show that at St. Paul's Pier at high water there was 12 per cent. of sea-water in the river, which seems incredible, as only a few years ago the Lambeth Waterworks took nearly the whole of their supply from a point very little above this spot, 13,849–54, 15,095–105. He points out further discrepancies between the estimates of Mr. Birch, Mr. Mansergh, and Professor Unwin, as to the amount of sewage, and the total volume of water, in the river, 13,854–5 Plan No. 30 which he hands in (*see Appendix B. J.*) shows by actual experiment with a float the course of the current. The float he used was different to those used by the Conservators which were too heavy to be amenable to the small variations of the current. He produces this float and explains it. Plan No. 30 refers only to the experiments made on the ebb tide. At Erith there is a considerable eddy owing to the river being abnormally large at this part in consequence of the extensive dredging going on. While the tide runs down with considerable velocity on the north side the yachts moored in Erith Bight have their heads in all directions, 13,930–3. He hands in Diagram No. 36 (*see Appendix B. K.*) which gives the float experiments on the flood tide. One float put into mid stream opposite Erith Pier only moved 300 feet in six minutes, which showed that in the Bight there was slack water at both ebb and flood, the tide keeping on the northern shore always, 13,933–4. He refers at some length to Mr. Baldwin Latham's evidence in regard to the float experiments, and contends that although the float, No. 3, arrived at Chiswick after 12 days' travel in consequence of the continued oscillation, the sewage could not have travelled up so far. He does not deny the *bonâ fides* of that experiment, but he is aware of what happened to it. He will not, however, pursue that subject any further, 13,947–58. His statement that 3,794 square miles of chalk drain into the Thames is taken from Mr. Prestwich's book on the Water bearing Strata about London, which he produces. The areas of the Orwell, the Stour, the Colne, the Blackwater, the Cam at Cambridge, the Little Ouse, are not included in the 3,794 square miles. The 4,000 square miles he obtained from the same source. Page 59 in the book gives the figures he has quoted, 15,047–62. Some extracts are read from Mr. Prestwich's book with a view to show that Mr. Law had picked out some streams which do not drain into the Thames, making a difference of 1,600 square miles out of the 3,794 square miles, 15,060–73. He has no facts to justify his assumption that the geological conditions of the Upper Thames Valley are the same as of the lower. It was merely to show that there was only half the rain allotted to the Thames below Teddington that came from above, 15,074–6. He does not know, nor do geologists know, how much of the water absorbed by the swallow-holes reappears upon a lower level of the same stream, or upon a level adjacent to that. The quantities which reappear in the Mole and the Stour are not at all equal to the quantities which disappear, 15,077–82. He did not know when he called attention to the discrepancies between Mr. Mansergh's and Mr. B. Latham's figures (*see Q.* 13,766 *et seq.*) that Mr. Mansergh had taken Sir Joseph Bazalgette's figures, while Mr. B. Latham made an independent calculation, 15,083–6. With regard to the statement that the water

MR. HENRY LAW—*continued.*

DISTRIBUTION OF THE SEWAGE IN THE RIVER BY THE VARIOUS MOTIONS OF THE WATER—*continued.*

at St. Paul's Pier contained 12 per cent. of sea-water, and that the Lambeth Waterworks used to draw their supply of water from that locality, they took it as far as they were able on the ebb and not on the flood tide. He is unable to say off hand what proportion of sea-water in pure water is necessary to make it undrinkable. It is the sulphate of soda rather than the chlorine which would make it nauseous. He says that the water was not mixed with other water before being delivered to the houses. He has made no experiments to ascertain how little sea-water he could taste, and knows no more on the subject than anyone present, 15,095–113.

POPULATION TO BE PROVIDED FOR.—He hands in Table No. 1, which gives the population of the metropolis in 1881, and the number of people draining into the three main sewers on the north and south sides of the Thames respectively. Tables 2 and 3 give the population draining into the same sewers for each of the districts, and Table 4 gives the population for each of the districts, the amount of sewage intercepted during the 24 hours, and the time occupied in flowing from the point of interception to the outfall, 13,650. On Plan No. 29, there are 80 districts into which he has divided London, and of these 29 districts have been steadily decreasing in population for the last two censuses, and he has shaded or cross-hatched those districts. The diminution occurs in the number of people who sleep in those districts, and he points out that the centre of London will continue to decrease, while the future increase of London will be round the margin or outskirts of London. Consequently the additional sewage which has to be brought in will be brought in at hours when the existing sewage is not running at its maximum, and that is an important point, when considering the size to be given to the sewers. The principles upon which the drainage of a city of 117 square miles is laid out are very different indeed from those of a country town, 13,693–5, 13,700–3. He will supply the populations of the districts which are decreasing, 13,701–2. He does not think the sewage in the centre of London has diminished during the day, but as the water from baths taken in the morning forms the largest element of the supply of water to the sewers, he feels confident there must be a diminution of sewage, though he does not wish to suggest that the diminution is anything like the ratio of decrease in population, 13,703–8, 15,026–32. Mr. Latham stated that the increase of London was going on as it had done for some considerable time before, and he wishes to show that not only is that ratio not going on so rapidly as it did, that it is what is called a decremental rate of increase; but also that as that increase takes place round the margin of London, it does not affect the sewers at the time when the maximum flow takes place from the centre of London itself; there would be a more gradual flow from the sewers, and they would be filled at times when now they are not filled, 13,709–10.

CAPACITY OF THE MAIN DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT: INFLUENCE OF THIS ON THE STORM DISCHARGES. — He has very carefully considered the evidence of Mr. Baldwin Latham, the general tenour of which was that "the increase of "London had outgrown the proportions of the drainage "system, and that, in consequence, whenever rain fell, it "became inevitable that that rain would be discharged "at one point or another by the storm overflows." In order to determine how far that was the case, he hands in a plan (*see Diagram No. 22, Appendix N.*), which shows by the heavy dotted line the district of the Metropolitan Board of Works, the coloured portions representing the area drained, and the parts left white show the undrained area, 13,645–8. The districts drained by the respective sewers are divided and numbered, and the population is divided accordingly. Mr. Latham took the population of "Registration London" as being more or less identical with drained London, which contained about 3,814,571 persons on both sides of the Thames, whereas he has taken Metropolitan London, which contains 3,832,441 persons. The district drained contains 3,880,102 persons, and the population of North Woolwich is included in the numbers on the south side of the Thames. He hands in Table No. 1, which gives the population of the metropolis and the number of people draining into each of the three main sewers, north and south. Tables 2 and 3, which he hands in, give the population draining into middle, high, and low-level sewers respectively for

MR. HENRY LAW—*continued.*

CAPACITY OF THE MAIN DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT; INFLUENCE OF THIS ON THE STORM DISCHARGES—*continued.*

each of the districts, and therefore affords data for arriving at the quantity of sewage. Table 4 gives the population of each of those districts, and the quantity of sewage which would be given off by each of those districts, 13,648–50, 14,919–30. Table 4 also gives the time occupied by the sewage in flowing from the point of interception to the main outfall, 13,650. If the sewers were trebled in size there would still be times when the storm discharges would overflow, 13,651–2. In order to determine the hour at which the maximum flow from each branch sewer will come down into the intercepting sewer, he has adopted the gaugings taken by Mr. John Taylor for the referees to the metropolitan drainage scheme, and which appear in a table in the Report made on that scheme in 1857. He has prepared a diagram from that Table, which shows that the minimum flow of sewage is at 4 a.m., the maximum flow is at 10 a.m., when it falls until 3 p.m. It then rises and again falls down towards midnight. On this basis he prepared Table 4, and he now hands in the diagram (*see No. 23, Appendix A. O.*) The same sewers are in existence now as they were in 1857, 13,652–3, 14,931–51. In diagram 24 (*Appendix A. P.*), the vertical height between the line A. A. and the line B. B., is equal to the total discharging capacity of the outfall sewer at Barking, viz., 34,764 cubic feet per minute, and the part coloured red on the diagram shows at each hour how much of that discharging capacity would really be occupied in carrying away the sewage at that particular hour; and it will be seen that the maximum flow is at half-past 2, and that it amounts to 15,000 cubic feet per minute in dry weather, without rain, 13,653, 14,952–61. Diagram No. 33 (*Appendix A. Q.*), gives a section of the northern high, middle, and low-level sewers, showing the height to which they would be filled by the maximum flow of sewage at the present time, or dry weather flow. The maximum discharging capacity of the middle, and low-level sewers is 31,144 cubic feet, whereas the total discharging capacity at the time of the maximum flow is 14,358 cubic feet per minute, or less than half the quantity they are capable of discharging, leaving out rainfall, 13,653–7, 15,007–17. He has prepared Table No. 5, which gives the area of Registration London, Metropolitan London, and Drained London, the totals for which are as follows. (*For details see the table itself.*)

| — | Registration London. | Metropolitan London. | Drained London. |
|---|---|---|---|
| | Acres. | Acres. | Acres. |
| On the North | 78,080 | 31,318 | 32,158 |
| On the South | | 43,229 | 32,843 |
| Totals - - | 78,080 | 74,547 | 65,001 |

65,001 acres are equal to 101·56 square miles, 13,658, 14,967. He hands in Tables 6 and 7, showing the areas of the districts drained on each side of the Thames, the density of the population, and the rainfall discharged into the sewers. Where the population reached 80 to the acre, or exceeded that number, he has taken the whole of the rainfall as going into the sewers, and where the population is less than 80 to the acre, he has taken only half the amount as going in, because in a sparsely populated district it falls on the ground and is absorbed. If the population is dense it falls on the roofs or paved streets, and so finds its way into the sewers, 13,658–60, 14,967–75, 15,000–3. He has assumed that, if rain falls at any spot, for instance at Hampstead, the time it would take to traverse the local sewers before it reaches the great sewer would be 180 feet to a minute, which is, he thinks, a fair and proper velocity to give, and the diagram No. 25, which he hands in (*Appendix A. R.*), shows the time the sewage occupies in traversing the sewer before it reaches Barking, assuming the sewer to be running half full. In that diagram he has assumed that the rain commences to fall at the same time all over London, and that it falls continuously at the rate of a quarter of an inch every 24 hours without cessation for any period you please. It will then be 2½ hours before the first rain, which will be that of Bow, reaches Barking,

Mr. HENRY LAW—*continued.*

Capacity of the Main Drainage System as compared with the Demands upon it: Influence of this on the Storm Discharges—*continued.*

because the outfall sewers are not sewers of reception but of conveyance only; they receive nothing after Abbey Mills. The diagram shows the successive increments of rain in the sewer until it has received its full quantity, which would be delivered for ever if the rain continued at that rate. The figures at the bottom are intervals of time before any given quantity will arrive. If the maximum rainfall be applied to the maximum of sewage, it will be seen that a discharging capacity of 6,000 cubic feet per minute is left in the sewers, which if a very different state of things to that alleged by Mr. Latham. He has made this diagram in duplicate so that the scale of the diagram (in blue) may be applied to the scale of the diagram (in red), 13,661–7, 14,976–82. A velocity of 120 feet is a self-cleansing velocity, and is considered a very good velocity. 180 feet is a high velocity, 15,197–9. If it rained with a steady rain for a week at the rate of a quarter of an inch per diem, the quantity of rain coming off the ground would amount to 14,000 cubic feet per minute, and there would in such an extreme case be an equable flow throughout, 13,668–70. The sewers are capable of carrying off this quantity of continuous rain, leaving a surplus discharging capacity of between 5,000 and 6,000 cubic feet a minute, 13,671–4. The flow of the sewage is remarkably uniform until 9 at night, owing to the time sewage takes to reach Barking from a distance. It takes 9½ hours to flow from Chiswick to Barking. The pink diagram shows how uniform is the flow of the sewage. Mr. Latham stated in his evidence, that whenever it rained the storm overflows came into action at some part or other of the river, and he deemed it right to investigate fully such an important statement. He is glad to find that this statement has been corrected, 13,675–8, 13,685–6, 15,004–6. He has also investigated Dr. Frankland's statement, that, however slight the shower, four-fifths falls into the sewers, leaving one-fifth for evaporation. He finds Dr. Frankland has calculated his quantities on very imperfect data, 13 671–84, 14,996–15,003. There is no doubt that rain falls at times in excess of a quarter of an inch in 24 hours, but it must be borne in mind that there is a very large area unoccupied in the sewers, even when the maximum flow of sewage is taking place. The vacant space in the high level sewer (along its whole length), is 1,362,350 cubic feet; in the middle level sewer it is 1,115,290 cubic feet; and in the low level sewer it is 1,675,623 cubic feet; and, in the three outfall sewers, 2,715,180 cubic feet, giving in all a total of 6,868,443 cubic feet, which is equal to eight hours' rainfall, and this must be filled by rain before the sewers would become sufficiently filled to overflow by the storm overflows, 13,685–8. Mr. Latham stated that the joint discharging capacity of the three sewers was in excess of that of the outfall sewer, but it is not so, because the sewers were constructed to carry off a proportionate quantity of sewage at different times. The time of greatest discharge is different for each sewer. If the sewers had to discharge all their maximum at once 1,680 six-inch sewers would be required to carry off the sewage of the whole of London, which, estimated at 40 cubic feet per minute from 490,000 houses, gives a total of 19,600,000 cubic feet per minute, and this is absurd. Before the three sewers are united, storm overflows are provided to relieve the sewers because it was practically impossible to design the sewers so that they might be competent to deal with the whole of the rainfall which might be delivered to them under extraordinary circumstances; but that is vastly different to saying that whenever rain falls the storm overflows come into play, 13,689–91. He has not come to any conclusion as to the number of times the storm overflows should come into operation, but the result of his calculation bears out the reasonableness of the return which has been furnished from observation. The figures which he has given of the capacity of the sewers to be filled up by sudden falls of rain apply simply to the intercepting sewers, and a very large number of hours would elapse before an overflow occurred, even after heavy rain. He quotes an extract from the Report of Mr. John Taylor to the Referees as the result of his observations of the gaugings during heavy storms of rain, from which it appears that no definite quantity can be pronounced to flow off any given district with a given fall as so much depends on the previous state of the ground, on the quantity of rain falling in a given time, and the duration

Mr. HENRY LAW—*continued.*

Capacity of the Main Drainage System as compared with the Demands upon it; Influence of this on the Storm Discharges—*continued.*

of the fall. In a town district the quantity of rain running off in six hours varies from 10 to 60 per cent. of the quantities fallen; while in a suburban district it varies from 0 to 30 or 40 per cent. in 24 hours after the rain has fallen. In one case after a rainfall of one inch in 1¼ hours, 65 per cent. ran off within 15 hours of the fall, viz.:—46 per cent. in three-quarters of an hour after the rain ceased; 14 per cent. more in the next 6¾ hours; and 5 per cent. more in the next 7½ hours. In his calculations he admits of 70 per cent. running off, which is in excess of that which really happens. The result is this, that while the discharging capacity of the sewer (when it reaches the lip of the sewer) is 34,764 cubic feet per minute, the maximum of the sewage will be 15,070, and the rainfall 14,242, leaving a surplus of 5,452 as the carrying capacity of the sewers with the maximum sewage and rainfall, which would be available for increase of population, 13,692–4. For a month past, in consequence of some experiment being made, one of the outfall sewers has been temporarily diverted from its use, the whole of the sewage being turned into the other two sewers, and the maximum time and the quantity of sewage are singularly confirmatory of the conclusion he has drawn here from these figures. The result is that the two sewers have taken the whole sewage, one being filled to a depth of 3 feet 9 inches, and the other had 4 feet of sewage in it. After a very heavy fall of rain only six to seven inches extra were gauged, 13,710–14. The storm overflow was not at work because the sewers were not full. Before an overflow can take place the carrying capacity of the sewers must be exhausted, and the sewers must be filled. Then they overflow, as the rain or sewage would be headed back. If the sewers were of such a capacity that a shower of rain would fill them more quickly than they could discharge themselves, there would be an overflow, but in such a hypothetical case the sewers must absorb an enormous quantity of water before they can be filled, and it must be borne in mind that the contents of the sewers are not stagnant water, but that they flow with great speed, increasing in velocity as the sewer gets fuller, 13,714–9. He has ascertained that the quantity of rain which fell last Saturday (26th May 1883) between 9 a.m. and 12.15 p.m. was $\frac{17}{100}$ths of an inch, and between 4.30 p.m. and 6 p.m. $\frac{15}{100}$ths, making a total of one-third of an inch in 9½ hours, and although only two sewers were at work no overflow occurred at any part of the system. A drizzling rain fell during the interval from 12.15 p.m. and 4.30 p.m., and the system which was provided for a quarter of an inch in 24 hours with three sewers was sufficient to take one-third of an inch of rain when only two sewers were at work during the maximum flow of sewage, which occurred at 2.30 p.m., without any overflow at all, 13,847–8. He disputes Dr. Frankland's statement that $\frac{1}{100}$th part of an inch of rain in 24 hours would increase the flow of sewage at Barking by 14,000,000 gallons daily. Not a particle could ever reach the sewers because it would be dissipated by evaporation, 13,889–90, 15,126–8. It was not intended by the Metropolitan Board of Works to make another main sewer in the north to prevent the overflow during storms, but they are building a new sewer to carry off the storm waters. The works the Board has in contemplation, but which await the decision of this Commission before carrying them out, are the enlargement of the reservoirs at Barking and Crossness, so as to avoid the necessity of letting the sewage pass out during the flood or continuing so long during the ebb, 13,974. He is acquainted with Sir J. Bazalgette's evidence, and knows he stated that the rainfall at Greenwich and Kew did not correspond at all, but he has not examined Mr. Symon's tables with the view to form any opinion as to the coincidence of rain at those places. The tables of Greenwich rainfall were not prepared by him nor under his superintendence, 14,870–80. He differs from Mr. B. Latham in thinking that the population and the sewage requirements of London have outgrown the drainage system, 14,881–2. He attributes the necessity for the increase of large storm overflows to the fact that owing to the greater surfaces which contribute the rain to the sewers a larger quantity of rain is carried away through the sewers. New sewers to relieve existing sewers have been or are being constructed at Vauxhall, Wapping, Deptford, and the Fleet Valley; he will, however, obtain a list of all the storm overflows which have been provided within the last ten years, 14,880–

## Mr. HENRY LAW—*continued.*

CAPACITY OF THE MAIN DRAINAGE SYSTEM AS COMPARED WITH THE DEMANDS UPON IT; INFLUENCE OF THIS ON THE STORM DISCHARGES—*continued.*

903. The increase in the population, together with the increase in amount of paved streets, which brings more rain into the sewers, brings with it an increase in the sewage as well, 14,904–10. The population has increased in the Hackney Valley, Effra Valley, and Quaggy districts (*see Diagram No.* 22), but that plan does not show in which districts provision was made for a quarter and an eighth of an inch of rain respectively; he is not aware that in those districts where an eighth of an inch was provided for, a large increase in population and building has taken place, 14,911–8. He still asserts that allowing for the increase in the population, the main sewers are adequate to carry off the whole of the sewage. They are, in fact, capable of carrying off more than double the quantity they were originally designed to take, 14,919–30. He used Mr. John Taylor's gaugings to ascertain the hourly flow, not the quantity, of dry weather sewage; and the inaccuracies in those gaugings which have been pointed out by Sir J. Bazalgette and others, do not impugn the use he has made of the gaugings, because he made use of the dry weather gaugings only, 14,931–51. The high and the middle level sewers flow by gravitation; it is only the contents of the low level sewer that are pumped at Abbey Mills. The maximum flow of the high level sewer is 1,800 cubic feet a minute, that of the middle level sewer 7,788 cubic feet a minute, and the low level sewer is 6,570 cubic feet a minute. Out of the total amount of 15,000 cubic feet a minute, about 6,000 cubic feet are pumped, 14,952–66. He is not aware that the Metropolitan Board of Works gauged the sewers in 1865 to ascertain the velocity of the flow through them. No trace exists in the Board's offices of any such gauging, and the books produced, which are signed by a man named Wa er, he believes to be gaugings taken by the Essex Recl . ation Company; they have no connection with the M tropolitan Board of Works, 14,983–8. Diagram No. 25 only shows the increase in the quantity of rain discharged from the sewers up to ten hours. After that it runs as a constant quantity at the given rate, 14,989–90. He repeats that the carrying capacity of the sewers is more than sufficient to carry off a quarter of an inch of rain in 24 hours. and when they are carrying off that quantity with the maximum flow of sewage, they have a surplus capacity of 5,452 cubic feet per minute. When the rain exceeds that surplus then the sewers overflow, 14,991–5. He is not aware that Mr. B. Latham referred to rain which was over $\frac{1}{100}$th of an inch in an hour, when he referred to the overflow at some point or another. Mr. Latham made no such qualification about it, 15,004–6. The total discharging capacity of the high level sewer is 16,620 cubic feet a minute, the middle level sewer is also 16,620 cubic feet, and the low level sewer is 14,524 cubic feet a minute, making a total discharging capacity at Abbey Mills of 47,464 cubic feet a minute. They are capable of discharging this quantity for a quarter of a mile. From Abbey Mills the three sewers cease to be intercepting sewers, and become sewers of discharge. Their united discharging capacity from that point is 34,764 cubic feet a minute, 15,007–25. The sewage at Crossness does not fall into the river, but is conducted by pipes to the bed of the river, whence it issues below low-water mark by means of the pressure of the sewage in the reservoir. The outlet never gets covered with gravel or anything of that kind, and it is never silted up. The outlet is always covered by water. At Barking the sewage outfall is covered at high water, but is visible at low-water, and the sewage can be seen as it is discharged. The beach at Barking is very short, and although the Crossness system of discharging could be carried out there, he is doubtful, when the reservoirs are enlarged, whether it would be an improvement. Under present circumstances the Crossness system is preferable to that at Barking (*see* remarks after Q. 14,571, evidence of 38th day). Referring to his answer to Q. 13,847 when he stated that none of the storm overflows were at work on a certain day when rain fell, he is not aware that the Blackfriars sewer was overflowing the whole day, but he will inquire into it, 15,091–4. The considerable number of storm overflows, which have been constructed of late years, must not be taken as showing that the drainage system is not sufficient to carry off the sewage, because the natural watercourses having been filled up, it has been necessary to substitute artificial watercourses in the shape of overflows, or, more properly, relief sewers, for them, 15,200–2.

## Mr. JOHN WILLIAM TRIPE, M.D., M.R.C.P. Edin.

President of the Society of Medical Officers of Health, and Medical Officer of Health for the Hackney District.

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS.—For some time past he has been investigating what influence the river has on the health of the riverine districts, and he selected as the most suitable places for the purposes of his inquiry, Greenhithe, Erith, Woolwich, Greenwich, and Rotherhithe. These sites he visited, and went very carefully over the whole of the districts, noting the class of houses, the complexions and general appearance of the people, and the condition of the children especially. The districts and streets which he visited are set out upon the maps which he hands in. (*See Appendices, B. R.* 1, 2, 3, *and* 4.), 13,977–80. He also obtained the number of deaths from the seven zymotic diseases, marking on the maps the exact spots where they occurred in streets running at right angles to, or at an acute angle with, the river, and in the case of those parallel with the river they are simply marked, as it is not of so much importance, 13,980. He took the years 1878, 1879, 1880, and 1881, as they afforded a sufficiently long period for his purpose, and included hot and cold weather, as well as in some of the years an epidemic of scarlet and typhoid fevers, and to a certain extent diphtheria. From the Registrar-General's returns of deaths he made out his spot maps, which he thinks are of greater value than percentages of deaths, because it will be seen that the greater part of the deaths have occurred away from the river. Another important point is that, as a rule, in the small courts and places near the river, where the people are poorest, and there is most crowding, the deaths are fewer in number than in the streets farther away, 13,981–2, 14,042, 14,189–93. He has included also the deaths in the Greenwich Infirmary, and in the Deptford and Stockwell Fever Hospitals, in order to make the record as accurate as possible. The percentage of deaths from zymotic diseases as compared with deaths from all causes in the four years 1878–81, is shown in Table I., 13,983–4, 14,167–73. The seven zymotic diseases are small-pox, measles, scarlet-fever, diphtheria, whooping-cough, typhoid, and diarrhœa. In addition to those, he has separated typhus from typhoid; otherwise an erroneous impression would have been created, as in Rotherhithe there was a severe outbreak of typhus which resulted in several deaths in private houses and in the hospitals, 13,985. On the maps the red spots indicate scarlet fever, yellow indicates typhoid, blue, diphtheria, and black, diarrhœa, 13,986. He has been unable to prepare a spot map for Greenhithe, as there were no data of the zymotic diseases for that place at the Registrar-General's office, 13,982–7. In Erith, during the four years there were only ten deaths altogether from zymotic diseases. It is a very healthy place, 13,987–9, 14,104. Zymotic diseases are comparatively rare on the margin of the river at Erith, (that is to say, within a quarter of a mile from the river,) more deaths occurring from those causes in the area further away, 13,990–2. At Woolwich in the four years there were 10 deaths from zymotic diseases near the river, and that district is occupied by very low classes of people living in very poor habitations, and they are exceedingly liable to suffer from these diseases. The deaths in the district further away from the river are much greater, although the class of inhabitants is better, and the population is not so dense. The part of Woolwich he has tabulated ought *a priori* to be very unhealthy, but, as a matter of fact, in that part of Woolwich there is proportionately less zymotic disease than there is in all London, 13,993–7, 14,134–7. Table 2 gives the average annual death-rates from zymotic diseases for two decennial periods, viz., 1856–1865, and 1871–1880. The death-rates in the first period are corrected for excessive death-rates from zymotic diseases all over London during that period, 13,998. Taking Greenwich and Woolwich together from 1856 to 1865, before the sewage was taken there, the zymotic death-rate was 3·95 per 1,000, but from 1871 to 1880, when the sewage is taken there, the zymotic death-rate is positively less, viz., 3·47 per 1,000. So, when the sewage was taken away from Bermondsey, in St. Olave's there was an increase in the number of deaths from zymotic diseases, and when the sewage was taken down to certain places the death-rate decreases in those places, 13,999–14,000, 14,155–63. Greenwich has always had an excess of diarrhœa, but he cannot explain the reason why; if the severe

MR. JOHN WILLIAM TRIPE—*continued.*

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS—*continued.*

epidemic of 1866 be deducted from the total zymotic death-rate of 18·18 per 100, it would be reduced to about 14. The parts which are densest in population appear to suffer least, and possibly it is due to the fact that the air from the river blows out the bad air from the houses, and there is nothing injurious carried from the river into the houses, 14,001–2, 14,021–4, 14,146. The diseases which are most likely to arise from the emanations from the river are not found in the vicinity of the river, 14,003–4. There are very few warehouses on the river bank in proportion to the number of dwellings, as compared with the area further in, 14,005–9. Of the solitary death from diphtheria in Rotherhithe Street, it was really a case of diphtheria peritonitis, which can hardly be considered to be a death from diphtheria, so that if this be eliminated from the tables, diphtheria in the neighbourhood of that part of the river disappears, 14,010–11, 14,018. As regards hospitals he only obtained statistics as to deaths, but none as to recoveries, 14,012–13. He thinks the death-rate is a fair criterion of the ratio of disease, he knows of no more reliable method, 14,014–7. The Greenwich area is more limited than it would have been if he had decided on the spot map system at first. He was unable to obtain the census from Somerset House, so that the only census he had was that of the training ships; and therefore he adopted the per-centage of zymotic diseases to total deaths. Nearly the whole of the river frontage at Greenwich is occupied by wharves and quays, and in the four years there has been only one death from scarlet-fever near the river, and that was in Bennett Street. There was one in Newcastle Street, an eighth of a mile from the river, but all the other cases were in the streets about the middle of the area or further away, 14,018, 14,103–15, 14,116. Except the block of houses between Paradise Street and Rotherhithe Street, the river frontage at Rotherhithe is quite blank; the neighbourhood is very poor, and much crowded. In that small bit of the district there have been a large number of deaths from scarlet-fever, and one from diphtheria, but none from diarrhœa or typhoid, 14,018. In Princess Street, which runs at right angles to the river, there were two deaths from diphtheria, one from diarrhœa, two from scarlet-fever, and two from typhoid fever. It is the only instance of that kind of thing occurring, and these cases are distributed partly near the river and partly away from it. There is a similar kind of aggregation of disease in Adam Street, Albion Street, and Risdon Street, but, as the map shows, along the bank and along Rotherhithe Street, there is nothing of the kind. Elephant Lane is a much poorer street than Princes Street, but it was free from diarrhœa, 14019–20. From the Supplement to the 35th Report of the Registrar-General he obtained some figures which enabled him to compare the deaths from zymotic diseases with the deaths from all causes, which proved that he was right in adopting that basis. The results he obtained are as follows:—

TABLE showing the NUMBER of DEATHS in ENGLAND and LIVERPOOL from all CAUSES and from ZYMOTIC DISEASES to 100 DEATHS in the HEALTHY DISTRICTS from 1861–1870.

| ——— | Healthy Districts. | England. | Liverpool. |
|---|---|---|---|
| Deaths at all ages and from all causes | 100 | 138 | 229 |
| Deaths at all ages from seven chief zymotic diseases | 100 | 140 | 232 |

Applying that to the selected districts for the four years 1878 to 1881, the zymotic death-rate in all London was 16·23 per 100 deaths from all causes, whilst in the riverine selected areas it was—

| | |
|---|---|
| In Greenhithe | 12·85 |
| In Erith | 13·26 |
| In Woolwich | 11·14 |
| In Greenwich | 18·88 |
| In Rotherhithe | 23·67 |



MR. JOHN WILLIAM TRIPE—*continued.*

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS—*continued.*

The excess in Greenwich arose from measles and diarrhœa, which, as shown in Table 1 were enormously high as compared with the returns for the other districts. If this excess were reduced to an average, allowing for an increase in scarlet fever, which was diminished by the measles, the average zymotic death-rate in Greenwich it may fairly be assumed would be about 14·5 or 15 per cent. of the total deaths as compared with the London death-rate of 16·23, 14,025–8, 14,140–1. The singular coincidence as regards the large number of deaths from measles and diarrhœa at Greenwich does not suggest that similar causes may have produced them, because diarrhœa has not been so prevalent to the same extent during any period except those four years, 14,029. Measles and whooping-cough are in no way connected with sewage, and he has therefore struck them out of his spot map, 14,030. He accounts for the deaths from zymotic diseases in Rotherhithe being higher than in any other parts of London, chiefly by the character of the population and the number of children, and mentions the case of Liverpool as a proof of his statement, where there is a very large number of children, and where the death-rate of children under five years of age from zymotic diseases as compared with deaths from all causes amongst children under five is 343 to 262, which is double the number in all England, 14,031–4, 14,140–1. He agrees with Dr. Corfield in thinking that the high death-rate from zymotic diseases in St. Olave's, Southwark, was not caused by the river, and the spot map fairly corroborates this, but not to the same extent in other districts, 14,035–7. Dr. Corfield's tables are not reliable to a certain extent for comparison, because the deaths which occurred in hospitals from fever and small-pox are not distributed to the parishes from which they were brought, and also because *all* fevers were grouped together under one head, instead of being properly classified, 14,037–9, 14,174–82. He does not believe that the river or the drains by themselves, irrespective of germs, ever caused typhoid fever, small-pox, scarlet fever, or whooping cough; but he believes that insanitary conditions render persons more susceptible to taking the disease, and that they are likely to prove more intense by debility and a bad state of the blood. Dr. Corfield also looked on scarlet fever as being more likely to be influenced by the river, while the spot map shows that there is very little scarlet fever near the river, except in Rotherhithe. Table 2 is a comparison between his statistics and Dr. Corfield's, 14,039–40, 14,042, 14,174–84. He selected zymotic diseases as a test for sewage contamination, because they are considered to be the diseases which chiefly arise from or are affected by sewer emanations or emanations of that kind. Throat diseases are often caused or made much worse by sewer emanations, 14,043–5. Speaking generally, Greenwich and Woolwich are healthy, Dartford and Gravesend are very healthy, and Hoo is singularly healthy, the death-rate at this latter place being only about 14, and yet the zymotic death-rate was higher in the years 1856 to 1865, when the sewage was not there, than in 1871 to 1880, when it was there, 14,043, 14,046–7. He cannot suppose that the river emanations were blown over the houses on to the land beyond, except by very high winds. Except diphtheria, he knows of no other zymotic disease which is carried any distance by the wind. Small-pox has been stated to be carried by the wind, but it is entirely contrary to his experience. Supposing that it was possible for the emanations to be so carried, the effect would diminish as the square of the distance increases, inasmuch as the emanation, whatever it was, would become mixed with such a large quantity of air in being carried away, and the air would also oxidise it. The districts are mostly flat, except at Gravesend and Erith, where there is a little rising ground, 14,048–51. He hands in Table No. 5, which gives the annual average deaths from zymotic diseases from 1871 to 1880 for the sub-district of St. Olave's, Southwark, St. John, Horsleydown, St. James, Bermondsey, and Rotherhithe, and also for the sub-district of Leather Market and St. Mary, 14,040. The density of population in the latter sub-district is greater by 50 per cent. than the population in the former, and to a certain extent may affect the result obtained of the total zymotic death-rate, 14,052–3. He does not believe that the outbreaks of typhoid fever on board the training ships, on which Dr. Collingridge has given evidence, were in any way attributable to the river, for

## Mr. JOHN WILLIAM TRIPE—*continued.*

### Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

the sick were removed from the ships, and those who remained were perfectly healthy, although they were, so to speak, in the infected area. He thinks it possible that polluted water got by some means, possibly leakage, into the water supplied to the ships, which in itself is sufficient to produce typhoid fever. Another point mentioned by Dr. Collingridge, that when yachting he suffered from diarrhœa and sickness caused by the state of the river, he suggests that irregularity in taking meals and knocking about produced diarrhœa and dyspepsia, 14,054–62. The total population of the five training ships is 1,506, and the average death-rate for those on board the ships is about 4·2 per million, as against 6·72 per million for all England between the ages of 10 and 20. The average rate for all England is about 20 per million. He considers the continuance of the disease on board the ships was due to overcrowding, to the infectious nature of the disease, and to insufficient ventilation, 14,063–73. The captains have very wisely discontinued the use of the river water for any purpose whatever, 14,073, 14,185–8. If the water was drunk the boys would undoubtedly make themselves ill, 14,073–5. None of the medical officers to the Customs or police in their reports attribute any ailment of the men to any alleged injurious effect of the river, with the exception of Dr. Browning, whose evidence before this Commission is not corroborated by his reports to the surgeon-in-chief to the Thames Police. The chief causes of death reported by these doctors are pneumonia, rheumatism, and so on; zymotic and febrile disease, they say, being proportionately small, 14,076–82. On the foreshore at Erith, between the National Schools and the Lower Ballast Wharf, there are not many houses, with the exception of two or three rows of houses it is mostly open country. Between the ballast wharf and the pier the foreshore is mostly occupied by wharves, but there are certain gaps. The deaths recorded in the maps occur in the more populated parts of Erith and in the poorer neighbourhoods, 14,087–102. In Greenwich there were very few cases of zymotic disease upon the river side of Chester Street, although some of those streets comprise a very low class of houses. Then comes some waste land and Greenwich Park, and all that part of Greenwich from the Woolwich Road down to the wharves on the river is densely populated, and although it might be expected that disease would be rife there, no disease has been found. The ratio of the population between Chester Street and the river, and Chester Street and the district beyond, is in the proportion of two to three, 14,105–16, 14,194–7. At Woolwich the river frontage is covered almost entirely with wharves, workshops, gasworks, &c., but in that district very little is more than a quarter of a mile from the river, but the map shows that most of the disease is situated at the back rather than at the front near the river. The ratio of the population between High Street and the river, compared with between High Street and the back, is as one to two. He went over the district very carefully in order to come to a fair conclusion, 14,117–32, 14,194–7. With density of population scarlet fever has a tendency to increase, 14,133. The death-rate from scarlet fever in Greenwich and Woolwich for the 10 years was 1·03, and he would expect that the Woolwich rate would be far below London, but between 1871 and 1880 the rates were ·61 and ·60, 14,134–6. The density of population for Woolwich is 11·8, and for London is 46·9. The densest places, as a rule, are the worst, 14,137–40. The Liffey is a very narrow stream at Dublin, and is filthier than the Thames, and the two rivers should not be compared together. All round Dublin zymotic diseases are very rife indeed, and the rate of mortality is exceedingly high. Owing to the height of the river walls, there are some parts where the sewage in the Liffey within the city is not oxygenated at all, 14,147–54. The state of health of the lower districts, even after the sewage had been taken down, depends upon the seasons, and he does not attach so much importance to the death-rate statistics of the Registrar-General as he does to his spot maps. After them, his Table I. he regards as next in value. His tables and Dr. Corfield's are of about equal value, 14,164–5. Speaking generally, along the margin of the river the houses and rooms are small, and there is much overcrowding in consequence, but upon the whole the margin of the river enjoys a singular immunity from zymotic disease, 14,194–7.

## Mr. JOHN HOLMES GROVES.

Licensed Waterman, temporarily employed by the Metropolitan Board of Works.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls. — For the purposes of this inquiry he made some experiments with fish to test the state of the water in the river, 14,328–31. He got some eels from a Dutch vessel lying off Billingsgate, and put them in a box, which he lowered into the water at Erith, off the "Castalia." They remained there for seven weeks and then died. On another occasion he put some eels into a box at Greenwich, which was submerged to a depth of six feet. He then let it float down the river as far as Erith and return on the flood past both the outfalls. If anything, there appeared to be an improvement in the eels after their voyage. He then moored the box at Greenwich, and they lived for two months, when the box was stolen or broken up, 14,364–7, 14,377–97.

Distribution of the Sewage in the River by the various Motions in the Water.—In October 1882 he was employed by Messrs. Law and Chatterton, together with a man named Gadsdon, to take soundings of the river. On the 16th of that month he was on the north bank of the river in Erith Roads laying out sections, when he saw a boat belonging to the Corporation of London apparently attached to a float, the float being ahead of the boat. The tide was flowing up, and there was a strong east-south-east wind blowing at the time. It is his opinion that if the boat was not attached to the float the velocity of the wind would have taken the boat right away from the float. The boat and the float remained in the same relative position to each other, viz., about two feet apart, while they remained in sight, which lasted for a quarter of an hour. He could not see that the float tilted at all, nor was there any drag attached to the boat to retard its progress. When he saw them they were to the south of mid-channel, 14,198, 14,232, 14,374–6. The men were in the bottom of the boat, out of sight, and had no oars out, 14,236–9. On the morning of the 19th October, at 6.15 a.m., Gadsdon and he were on the river in a boat going down to Erith on the ebb tide, the wind being south-east. About 20 yards from him he saw a Corporation boat to which a float was attached by a small line. The wind stopped the boat's progress, and the men in that boat were Mears and Whiting. The float was ahead of the boat, 14,240–56. His memoranda, which he produces, only contain notes of his own work, 14,258–64. On the 29th of October, at 5.30 a.m., he was on Greenwich Pier, and saw a float attached to a boat in which were two men, Tanner and Long. They rowed to the pier, made the boat fast, and remained on shore for 25 minutes. When they came back they towed the float into mid-stream and then cast it off. He knew this was wrong and reported it and the other cases to Mr. Chatterton in November, 14,265–77. On the 30th of October he was in his boat with four other men going home, when in Tripcock Reach to the south of mid-channel he came upon a boat very close in shore, both boat and float being aground. The latter was in an almost recumbent position. The tide was entirely slack, and two men in the boat, whom he recognised, were covered with a sail, and they were both asleep, 14,278–92. He has been employed by the Metropolitan Board of Works, off and on, for 19 years, and last October he was engaged first of all to watch the float operations, and to report anything which he saw that was wrong. He does not remember on what day the floats were first put into the water, but he thinks it was in September. His notes (in a book produced) relate to those experiments, and also to some experiments he made with fish to test the water for the purposes of this Inquiry, 14,293–331. He made his reports once a week to Mr. Chatterton. The floats were numbered, and he read the figure 4 on the float he saw on the 16th October. His notes do not follow each other consecutively. They were entered day by day, but in various parts of the book in an irregular manner. Whenever anything happened he invariably entered it in his book on the same day, 14,332–57, 14,374–6. On the 16th, 19th, and 30th October, the floats he saw were big ones; on the 29th October it was a small, or bucket, float. He is unable to give the number of the float in charge of Mears and Whiting, or of the one in charge of the men who were asleep. He knows it was a Corporation float, because he knew the men, 14,358–63, 14,368–73. He believes the float numbered 4 which he saw on his way home was the float which he saw attached to the boat on the morning of the 16th October, but he cannot say for certain, 14,374–6.

## Mr. CONRAD HENRY WALTER GRUNDTVIG.

Student at the Institution of Civil Engineers, and Pupil of Messrs. Law and Chatterton.

Distribution of the Sewage in the River by the various Motions of the Water.—On the 16th of October 1882, about 1 p.m., he was putting in pegs upon the north shore of the river for the purpose of taking sections, being assisted by Groves and Gadsdon, when he saw a boat passing up the river, in a line with Anchor Bay, stern foremost, and with a float attached to the bow. He identified it as a Corporation boat, both on account of the float, and also by the red flag in the stern. He could not see the number as the flag was lying down. He did not see the line by which the float was attached, but as it was slightly inclined he believed it was fastened to the boat, 14,398–406. On the same day he saw another boat going up the river broadside and whirling about, and the men had to use their oars to keep back the float. They kept together for a quarter of an hour when he lost sight of them as they swept round Coldharbour Point, 14,407–23

## Mr. JAMES EDWARD PETRIE.

Greenwich Waterman.

Distribution of the Sewage in the River by the various Motions of the Water.—On the night of the 15th October he was watching No. 6 float. He began at Bow Creek about 9 o'clock when the tide began to run up. The wind was east-north-east. At Millwall Pier he saw the men in charge of the float had fastened the float to the main or middle thwart of the boat, and it dragged the float along. They went as far as Fulham when the tide returned, and he followed them down to Greenwich. At Battersea Bridge, it being then daylight, he saw the men cast the float off because there was such a current the float might have knocked a hole in the boat. He was close to them all the time. The names of the men were Long and Hampshire, 14,424–44. He made notes at the time of all that occurred, and he produces copies of them. The originals were soaked with the rain which fell during the morning. The float was hurried up with the tide, because the boat was athwart the tide and the wind had great effect upon it. He had to use his sculls to keep his boat back to the float. In coming down the float went much faster than the boat, and he had to scull hard to keep up with it, 14,445–51. He had been watching this float for a fortnight, and was relieved at intervals as the Corporation men were also. They knew they were being watched. He did not enter this on his daily notes, as he would remember it when reported the result of his "drive" to Groves, who reported it to Messrs. Law and Chatterton. He had noticed no previous irregularity, 14,452–73. He was engaged in watching for about a month, but he saw nothing irregular after the 15th October. He reported this case to Groves within 12 hours after he observed it, 14,475–83.

## Mr. ARTHUR JAMES AVENT.

Greenwich Waterman.

Distribution of the Sewage in the River by the various Motions in the Water.—On the 30th October 1882 he was in a boat with Groves and Gadsdon, when he saw a float made fast to a boat, and the men who were in the boat were asleep under a sail. Their names were Taylor and Clements. This was in Tripcock Reach, as he was going home about a quarter-past five in the morning. As they passed the boat they hailed the men in the other boat, who jumped up from under the sail. He saw the line attached to the float, which was tied on to the boat's thwart, and the other two men who were with him could also see the line, 14,484–504.

## Mr. ANDREW WISE, L.R.C.P. Edin.

Physician and Surgeon.

Effect upon Health in the Neighbourhood of the Main Outfalls.—He lives at 207, Burrage Road, Plumstead, and since the opening of the outfalls has attended the people employed by the Metropolitan Board of Works, who live at Crossness. Their health is quite as good as that of people residing elsewhere, 14,505–7, 14,533, 14,558–62. He has been unable to trace any diseases there to the influence of sewage; there is no

## Mr. ANDREW WISE—*continued.*

Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

larger proportion of diarrhœa or zymotic disease prevalent there than elsewhere, and there has not been one case of typhoid fever amongst the 50 men employed there. Including children, the population of the place is about 150. Zymotic diseases are no more prevalent at Plumstead than elsewhere, and the influence of the discharge of the sewage into the river upon the health of the neighbourhood is nil, 14,508–16, 14,549–55. He has noticed bad smells in Plumstead, which are due to the factories on the river. Some of the cottages at Crossness are on the banks of the river, but there is no smell of sewage in the cottages themselves, 14,517–20. His opinion as to zymotic diseases is derived from a general impression and from his experience as a medical man in other places. It is not based in any way upon statistics, 14,521–7,14, 531–2. The smells he cannot describe, but they are very unpleasant, and he should say they are not due to sewage. He cannot trace any disease to these smells, 14,528–30. His district begins at Woolwich, and extends to Belvedere from Shooter's Hill. Belvedere is about two miles from the river, and stands on much higher ground than Crossness, 14,533–48. The cottages are situate not more than an eighth of a mile from the point where the sewage is actually discharged. He would recommend a site further away in the future, but from past experience he does not fear any evil results, 14,556–7. He does not attend the Crossness workmen's families in ordinary cases of illness, 14,563–7. In such cases he might be called in, but they have employed other doctors. He would be informed if any illness existed, even though he were not in attendance, 14,568–70. Sometimes several months elapse without his being called to the works, 14,571.

## Mr. JOHN DIXON, M.D., L.R.C.P., M.R.C.S., Lond. L.S.A.

Medical Officer of Health for the Bermondsey District.

Effect upon Health in the neighbourhood of the Main Outfalls.—He has held his present appointment for seven years, and previous to that he was Poor Law Medical Officer for 14 years for the waterside district of Bermondsey, which had an area of 391 acres, and a frontage to the river of half a mile. He has had 25 years' medical experience in Bermondsey, and lives at 133, Jamaica Road, Bermondsey, 14,572–81. There is no evidence in his district of any injurious effects on health from the sewage in the Thames. The riverside population was more dense than in the districts further back a few years ago, but some of the houses have been pulled down and warehouses have been built. Those houses which still remain are smaller and older than they are elsewhere in his district. The inhabitants are very much of the same class, 14,582–5. Typhoid fever has been below the average for several years, and there was only half the proportion of enteric fever which existed in London. For the whole parish there is more than the usual proportion of children, and in St. James's District, which is the riverside district, the proportion is the largest. The effect of this is, that there is more than the fair proportion of deaths from measles and whooping cough, and, in some years, from scarlet fever and infantile diarrhœa, and the zymotic death rate may be higher than that of London, though there is less fever. He has never seen any signs of sewage in Bermondsey or smelt it, 14,586–88. The river frontage always has been principally occupied by warehouses, graving docks, and shipping, but there are poor houses upon the opposite side of the Bermondsey wall within a few feet of the river. All through Rotherbithe there are no private houses by the river side, 14,589. He gives the boundaries of Bermondsey parish, which contains 626 acres, which is the area he referred to in mentioning the average of enteric fever. The length is about a mile and a half, and the breadth is one mile. There were only nine cases of enteric fever in twelve months, 14,590–7, 14,613–14. In the quarter of a square mile abutting on the river there were only two cases of fever, and it was doubtful whether they were enteric fever or not. He did not attend them. There were no cases of typhoid fever at all, 14,598–601. The average death rate for zymotic diseases in the parish of Bermondsey for the ten years from 1871 to 1880 is 4·60. Last year the rate per 1,000 was 4·80 as against 3·49 for London. Whooping cough was 2·03, London 1·20; measles 1·24, London

## Mr. JOHN DIXON—*continued.*

### Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

0·60. The excess from these diseases alone exceeded the excess above the general zymotic rate for London. The enteric fever rate for last year was London 0·25, Bermondsey 0·10, 14,602–12. During the last ten years the health of Bermondsey and his district has considerably improved, and he attributes it to the main drainage in a very large measure, and to the filling up of the tidal ditches which formerly existed, as well as to improvements in the dwellings of the poor, 14,615–16.

## Surgeon-Major CHARLES WILLIAM GRIFFITH, M.R.C.S., L.R.C.P.

Brigade-Surgeon in charge of the Magazine at Purfleet.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He has been stationed at Purfleet since November 1880, and his house is about 60 yards from the river. His garden runs down to the river. The hospital is about 35 yards from the river, and the barracks are from 200 to 300 yards distant, 14,617–23, 14,656–7. The river is discoloured at times, but he does not smell the sewage in the river at Purfleet. He has noticed a smell from a blood manure factory, and also from a glue factory at Rainham (Essex), and at or near Erith. Had the smell from the river been perceptible he would have been able to distinguish it. The factory smells are equally prevalent whether the tide is ebbing or flowing when the wind comes from the north-west or west, 14,625–33, 14,642–55. In hot weather he sits with his windows and doors open, and he has never smelt the river unless the local drains are out of order. The shore is composed of shingle and chalk stones; there is very little mud there, 14,637–41. He first noticed these smells early in 1881, and they are worse now because a new factory has been established at Rainham. This factory is close to the river bank, as nearly as possible in a line with the Rainham Railway Station. He knows the smell well; it is either a blood manure, or a glue manufactory. He does not know the exact position of the factory at Erith, but the smell is brought up with a south-west wind, 14,642–55. The river is not so likely to smell when there is a large quantity of land water in it, as it is when there is little or none, 14,671–3. The factory smells are very disagreeable, and having once smelt them they would be remembered. He cannot describe them. He knows very little of Erith, having only landed there occasionally, 14,679–81. He is distinctly of opinion that the smell is not from the river, and he has never smelt it with an easterly wind. The smells are chiefly noticeable in summer, 14,682–4. His men are not allowed to bathe in the river, on account of the strength of the current, and the under currents, which make it excessively dangerous. For these reasons he would not care to bathe in the river, and also the water is not so clean as he could wish it to be, 14,695–6.

Effect upon Health in the Neighbourhood of the Outfalls.—Speaking from the medical records of patients admitted to the hospital since 1876, they contain no cases of disease which can fairly be attributed to the emanations from the river, 14,624. There is no case of typhoid upon record, but one has recently occurred. Diarrhœa is not prevalent in the neighbourhood, and the general health of the troops and employés is very good, 14,634–6. The training ship "Cornwall" is moored about 500 yards below Purfleet on the Essex shore, and about 350 yards from the outfall. Typhoid fever is always more or less prevalent on board, and there is an outbreak now on the ship; but he does not know the number of cases. (The witness afterwards stated that his informant was wrong, there had been no case of typhoid, and the cases called so were scarlet fever.) He knows of one case of typhoid fever at Purfleet at the present time, and there are several cases of scarlet fever in the village now, 14,658–9. Purfleet is in the parish and registration sub-district of West Thurrock, and in the Orsett Union; he has nothing to do with the registration district, as he is only the medical officer for the barracks, 14,675–8. With regard to the outbreaks of typhoid fever on board the "Cornwall," he has occasionally visited the cases in consultation with the medical officer of the ship, and he has frequently seen cases for him in his absence. There is at present a case of typhoid in the quarters of one of the employés of the magazine, but he is a clerk in the employ of the London and Tilbury Railway Company. It is difficult to say when he contracted it, but he was at home when it broke out, 14,685–7. It is also difficult to attribute the outbreaks of typhoid on the "Cornwall" to any special cause. It is perfectly possible for a boy to have the seeds of the disease in him when he joins the ship, and communicate them to others. One case he believes was traced to that very cause. The "Cornwall" is the nearest training ship to the outfalls, 14,692–4, 14,697–8. He has about 300 people, men, women, and children under his charge. Of these 85 or 90 are troops, 14,688–91.

## Captain WILLIAM MILLER.

Captain of the Steamship "Castalia."

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He has commanded the "Castalia" ever since she was launched, and she has been stationed in Galleon's Reach and at Erith ever since. The ship is moored in Erith Reach in the full strength of the ebb, 14,699–703. He sees refuse and grease floating down on the ebb, but no excrementitious matter. There are no traces of sewage at all, 14,704–8. In the summer of 1881 he noticed a slight smell from the river at about the first shoot of the ebb, but not in 1882, 14,738–11, 14,750–64. He has repeatedly bathed in the river on the top of the tide during the last two years between the ship and the shore. The water then is clean and salt. He bathed a few times only in Galleon's Reach, 14,712–8. With a north-west wind he notices very bad smells from the factories on the river bank, particularly from a glue factory. He has often had to shut his cabin door to try to keep them out. With a south-west wind he notices a smell from some brickworks, but it is nothing like the factory smells, 14,725–34. He was in Galleon's Reach for about a year and a half and has been stationed at Erith since October 1878. The water in Galleon's Reach was not so inviting to bathe in as the water at Erith, because there is not such a head of water on the top of the tide, 14,735–49. When the tide is running out strong he could not bathe comfortably, 14,765. The sewage is discharged just after high water, and he has watched for its coming down very closely, because it was so much talked about at Erith, but he has never been able to detect it. The "Castalia" was removed from Galleon's Reach just after the "Princess Alice" disaster, because it was said that the twin ship obstructed the view, 14,766–72.

Effect upon Health in the Neighbourhood of the Main Outfalls.—With the exception of about 12 nights he has always slept on board the "Castalia," and has enjoyed excellent health. His crew consists of two men and a boy, and with the exception of a boy who had rheumatic fever and who died in the hospital at Erith there has been no case of illness on board, 14,719–24.

## Mr. EDGAR DOGGETT.

Assistant Accountant in the Office of the Metropolitan Board of Works.

Effect upon Health in the Neighbourhood of the Main Outfalls.—He has been employed in his present office for 20 years, and was in the Census Office for two years prior to that. During that time he had frequent experience in collecting and arranging statistics, 14,773–6. He assisted Dr. Tripe in his investigation of the sites which were likely to be affected by sewage (if there were any) by taking out the deaths which occurred in the various areas from the books of the Registrar-General, and visiting the localities themselves. He obtained further information from the office of the Metropolitan Asylums Board of the deaths from typhus, scarlet fever, enteric fever, and other diseases, except small-pox. These he tabulated and handed to Dr. Tripe, 14,777–82. The ordnance map of Erith shows a quantity of unoccupied space which is now built over. He has had this corrected to a certain extent on the map he produces. He went over the district shown on Dr. Tripe's

## Surgeon-Major C. W. GRIFFITH—*continued.*

### Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

## Mr. EDGAR DOGGETT—*continued.*

Effect upon Health in the Neighbourhood of the Main Outfalls—*continued.*

spot map of Erith, and no part of Erith can be considered to be densely populated. The houses are closest in that part which is adjacent to the river, and that part, as shown on the map, is remarkably free from spots, 14,783–94, 14,805–6. He went over the Woolwich selected area twice, and the most densely populated part is also that nearest the river. The area of that part is 460 feet on the south by 500 feet on the north, and is about 200 feet deep, and contains about 96,000 square feet. The most densely populated part of both Greenwich and Rotherhithe is also situated near the river, 14,795–803. The river frontage at Rotherhithe is occupied by wharves and public-houses, and the area he has referred to comes close up to these, 14,804–7.

## Mr. FRANCIS MEAD CORNER, M.R.C.S., L.S.A.

Medical Officer of Health for the South part of Poplar.

Popular Evidence as to the Foul State of the Water in the River near the Main Outfalls.—In 1857 there were great complaints of the state of the river, and there was a very unpleasant smell arising from it, 14,835–6, 14,840. He sees no sewage at Poplar, but in certain portions of the river banks there is a certain amount of mud, but he has had no complaints of bad smells from those who live there, nor has he noticed any smell when in the houses overlooking the river. It is worst at Blackwall by Bow Creek, but the steamers going up and down seem to cleanse the banks to a great extent by their wash, 14,847–51. On the "Dreadnought" nothing offensive was smelt when 15 to 20 feet above the river, but at the surface of the water, or a few feet above it, it was distinctly nasty. The smell would be experienced at a higher level, he thinks, when the air was still, more so than when a breeze was blowing. This smell was noticed generally by all on board, 14,863-9.

Effect upon Health in the Neighbourhood of the Main Outealls.—He has been Medical Officer of Health since September 1877, and his district extends from Blackwall to Limehouse. He has also been in practice at Poplar for 25 years, and attends all classes, including those employed upon the river, in the docks, and in the factories which are on the river, 14,810–16. There are many thousands of people employed in the factories who mostly live in his district, but he does not find that typhoid, diphtheria, diarrhœa, or other zymotic diseases are more prevalent amongst the riverside districts than in districts more removed from the river. He compares the monthly return of deaths and infectious diseases for his district with those of other districts, 14,818–29. During the last five years there has been an epidemic of scarlet fever in the Isle of Dogs, but it was traced to a Board School, and was in no way connected with the condition of the river, 14,829. From 1857 to 1868 he was Resident Medical Officer of the Seamen's Hospital Ship "Dreadnought" at Greenwich, and there were from 150 to 200 patients on board. At that time the river was in a very bad state, but it had no injurious effects on the patients, the attendants, or the officers. There was a very unpleasant smell from the river, 14,830–40, 14,857–61. There were a considerable number of cases of typhoid fever brought to the ship, but, with one exception during the two years he was there, it never spread. At Dr. Lethby's request he reported these facts to him privately, but he does not know what has become of the communication. He has no evidence to show that the metropolitan outfalls have not had an injurious effect upon the health of the inhabitants of Poplar, and therefore it must not be accepted as a fact, 14,481–6. The same remark applies also to London as regards the condition of the river in 1857 and 1858, but, as a medical man, he should expect that the sewage in the river would be injurious to health. He would attribute the decrease in the death-rate of London more to the removal of the cesspool system and the more rapid removal of the sewage by the sewage system, than to the fact that the sewage was moved from London to Barking. He believes that the health of London would be improved by taking the sewage out of the river, but he has no facts to support it, 14,852–62.

## Mr. EDWARD EASTON.

Civil Engineer.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—For 25 years he has acted as Engineer for the Commissioners of Levels from Woolwich to Gravesend for the preservation of the banks, and consequently is well acquainted with the river; he is also Engineer to the Commissioners of the Navigation of Dartford and Crayford Creeks, and Engineer to the South Essex Waterworks Company. He has designed and constructed a good many engineering works of different kinds on both sides of the river. He thinks that when the Main Drainage works were designed no more suitable position for the outfalls could have been selected. The river at that time had no habitations on its banks from Barking to Erith, and on either side were vast marshes. From time immemorial there have been established on the river a variety of stinking trades between Greenwich and Purfleet, and if any nuisance arose from the sewage it would be overpowered by the existing nuisances. There is no change in the circumstances to induce him to alter his opinion now, 15,203–7, 15,292–4. Erith has enormously increased in size and population since the outfalls were opened, and there is a marked change in the character of the population also. There are a number of factories carrying on noxious trades between Erith and Woolwich, and he knows them all well from his frequent inspections upon the river, 15,208–9. The sanitary condition of Erith has in no way improved since he made his Report in 1877 or 1878, and the works which he recommended have not been carried out as they ought to have been. If anything, the condition is more aggravated now by the increase in the population, 15,210–11. The whole of the drainage of Erith was then and is now turned into the river. There are three or four outfalls at Erith. He recommended that the sewage of Erith should be deodorized by the lime process at Jenningtree Point, and then discharged into the river. That would cause no offence at all, while the discharge of sewage into the bay of Erith at all times is very objectionable. Only the other day he saw particles of sewage floating about, not Metropolitan sewage, which was going clean past the bay; it was not fresh sewage, and he is sure of it, 15,211–21, 15,346–53, 15,358, 15,398–402. He has read the evidence relating to the chlorine experiments, and, as far as he is able to follow the argument, it is not at all conclusive or worth very much. It is almost impossible to take samples enough to show what the chlorine really is in the river, and the admixture of so much fresh water, which comes into the river from Deptford to the sea, would have the effect of upsetting the calculation. The water can be seen running into the river at various points between these two places, notably from Greenhithe marshes and at Grays, 15,235–8. On the 4th June 1883 he visited one of the Erith outfalls which he had not been near since 1877. An iron pipe was broken, and it was discharging sewage at about half tide on the shore. He noticed the smells from the factories, particularly the fish manure factory opposite Erith. It was a bad day for smelling on account of the strong breeze. But all the factories can be smelt at Erith and other places very distinctly, some of the cement works being especially offensive, 15,281, 15,291, 15,354–7. He obtained a sample of the sewage as it was being discharged from the culvert, and it was all absolute sewage; it could not be highly diluted. It contained a certain amount of débris, wood and straws, &c., as well as some brownish solids which were no doubt excrement. There was a very marked line in the river where the sewage ceased, which he traced down the river until it lost itself. It was the same with the Crossness discharge, although he arrived two hours after the discharge had begun; the line was distinct, running parallel to the river, and then striking towards the shore and joining the other line which came from Barking, 15,304–9. He does not think there is any nuisance in the river at all arising from sewage; if there is a nuisance to the people of Erith, it is from the local outfalls, 15,346–53. The samples of water which he took on the 4th June were all forwarded to the chemists of the Metropolitan Board of Works for analysis. They were all taken at an uniform depth of 2 feet below the surface, and the exact spot, the temperature, and the time, was marked on each bottle, 15,362–7. The channel by Messrs. Beadle Brothers' wharf is in close proximity to the main outfall sewers of Erith, and he is not surprised to hear that the men working in that channel have complained of

Mr. EDWARD EASTON—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

the nuisance, especially as No. 1 sewer pipe was broken, and discharging on the shore at half tide. It would be unpleasant, but not injurious to health, he thinks, 15,392–4.

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—From observation, and not from actual measurement, he does not think there is a greater accumulation of mud in Erith Bight than there always has been. It varies at different states of the tide, and the accumulation is due to the eddy which exists there, the water from one and a half hours to three hours each tide being in a state of rest. Taking Erith causeway and the front of Erith, he does not think the accumulation of mud has increased. It is being deposited and washed away constantly, and there is not a gradual increase, 15,224–7, 15,310–17. Although it may have been stated in evidence, he is not aware that the lengthening of the causeway was due to the increase of mud, or that certain mooring buoys which used to be afloat at low-water are now aground. He does not live at Erith, and certainly is more familiar with the mouth of Dartford Creek. He never was very frequently at Erith, though he knows it well. His information as to any deposit or accumulation of mud is derived more from reports which he would receive from the Inspector to the Commissioners of Levels, 15,228–32. The only remedy to get rid of these accumulations would be to alter the shape of the river, but there is no doubt that the mud shifts from tide to tide and according to the quantity of water coming down the river, 15,233–4. In speaking of the mud in Erith Bight, he refers to the shore of the river and not to mud banks in the river, 15,239, 15,310–11. He produces and hands in a plan which shows the difference of the line of mud bank between 1862 and 1879, which was prepared in connexion with the improvement of Dartford Creek. He does not believe that there has been any change during all those years. He is unable to say whether there has been any change since 1879, 15,240-3, 15,372–8. On the 4th June 1883 he obtained a sample of some sand at Crayfordness which was being dredged up. It was bright sand covered on the top with a very small thickness of black material or mud. It had no smell whatever, nor could he detect any smell when the spoon came out of the water. The sand wa, suitable for building purposes, or cement when washed, 15,272–9. He then obtained a sample of the mud at Erith Causeway, which he washed, and found it contained about 40 per cent. of sand, and the rest was composed principally of coal dust, bits of brick, &c. An analysis has been made of the mud, and it will be laid before the Commission. A pole was pushed into the mud in several places along the causeway, but he could detect no offensive smell on the pole, 15,281–9, 15,337–45, 15,368–71, 15,387–91. At Cubitt Town he obtained a sample of mud from a dredger nearly opposite the Thames Soap Works and the Greenwich Candle Works. That sample has been handed over to the chemists for analysis. He obtained other samples, but he will not specify these, 15,281, 15,289–90, 15,295–6, 15,368–71. Assuming that the sewage was discharged upon the ebb from the main outfalls, he cannot see how it could be deposited in Erith Bight; but, discharged as it is on the flood and mixed with the water of the river on its way down, some portion of it so mixed may find its way into Erith Bight when brought back with the tide. As at present discharged, it cannot flow into Erith Bight on its way down the river, nor can the solid substances in suspension be so deposited. Any deposit of animal matter at Erith must arise from local causes, viz., the Erith drainage, 15,297–301. He saw the Erith mud on the 4th June, but he has made no regular inspection of it since 1878, and he does not believe there is any more mud there now than there was in 1879. There is a small "hard" close to the head of the causeway, which is clean and has no covering of mud over it, and it extends about one-fourth of the way down to low water. There is no beach at Erith, but the shore slopes down nearly perpendicularly to the foreshore, 15,312–36. The blue line on the map he handed in shows the line of mud as taken from the Ordnance map of 1863 to 1866, and the black line represents the mud in 1879. He does not remember whether 1863 to 1866 were dry years and 1879 a wet year, but it would not make much difference, because the Dart is one of the chalk streams, and it is a tidal river as well as far as Dartford, so that

Mr. EDWARD EASTON—*continued.*

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*continued.*

the quantity of water issuing from Dartford Creek depends more upon the tide than it does upon the upland water, 15,372–9. The Thames water contains a certain quantity of suspended matter, part of which is of natural origin, part due to the suspended matter contained in the sewage, and part due to the solid matter which has been washed from the banks, and in places where there is slack water there is a tendency for this to deposit, Erith Bight being such a place. He would expect to see it also more or less all down the river. Where the current is slack the deposit would be composed of fine stuff like the sample he took at Erith Causeway; where it runs more freely the deposit is coarser like the Cubitt Town sample, and where the current is quicker the deposit approaches sharp sand and gravel. In every case probably upon the top there would be some traces of sewage, 15,383–6.

Effect upon Health in the Neighbourhood of the Main Outfalls. — Erith is not an unhealthy place, decidedly. If it is not all that can be desired, he would attribute it rather to the sanitary condition of the town itself than to the Metropolitan outfalls, 15,222–3.

Distribution of the Sewage in the River by the various Motions of the Water. — He has read the evidence relating to the chlorine experiments, and, as far as he is able to follow the argument, it is not at all conclusive or worth very much. It is almost impossible to take samples enough to show what the chlorine really is in the river, and the admixture of so much fresh water which comes into the river from Deptford to the sea would have the effect of upsetting the calculation. The water can be seen running into the river at various points between these two places, notably from Greenhithe Marshes and at Grays, 15,235–8. On the 4th of June last he went down the river, accompanied by Mr. Chatterton, and arrived at the Barking outfall half an hour after the reservoir had been discharging. On the first quarter ebb he put a float into the middle of the sewage close to the shore and to the northern outfall, and then followed it in a small boat, 15,244–53. The exact spot where the float was put was right over the discharging point. About half the contents of the reservoir had been discharged, and the smell was very strong, but constantly it was overpowered by the smells from the chemical and guano works, which were brought up on the east wind, more particularly Lawes' Chemical Works, 15,254–7. He followed the float until it had passed the guano works just below Barking Creek, and then went to Crossness, where he put another float into the river, a little below the outfall, in the flow of the sewage. It took a course parallel to the shore. By this time the Barking float was very nearly off Dagenham Jetty. He then went to Erith Bight and put a third float into the river, which remained stationary, as nearly as he could tell, while the northern outfall float had travelled about half a mile beyond it. It was now about half ebb tide, 15,258–66. The third float was put in about 120 yards from the shore, just opposite the Upper Ballast Wharf; one yacht was facing up stream, and all the rest were pointing in the opposite direction. There was not much wind, so he does not think the yachts were either wind-rode or tide-rode, but, as the float was stationary, that it was dead water at the time. This float was taken up, as it was no use trying further experiments at that time. The Barking float at 4.46 p.m. was in mid-stream off Crayfordness, and from a sample of water which he took there was no trace or smell of sewage whatever; all the Metropolitan sewage had entirely disappeared. At 5.5 p.m. the float was in mid-channel at the top of Long Reach, and here he took it out of the water, 15,266–72. He thinks the present mode of discharging the sewage at high water is the best way that can possibly be conceived, because it is then carried straight down the river. There might be times when it might be discharged before high-water, but it would depend very much upon the tide, 15,292–4. No better position for the outfalls could be found between Greenwich and Gravesend, 15,302–3. He only used three floats on the 4th June, 15,359–61. The third float, which was put into the river in Erith Bight, he explains, was not actually in the sewage from Crossness outfall, but near the shore, the sewage being out far beyond it, 15380–2. The easterly wind blowing would have an effect upon the water, but not upon the floats, which followed plainly in the stream of the sewage. The Crossness float was lost in the line of mid-channel, 15,395–7.

## Mr. ROBERT GORDON TATHAM, M.R.C.S., L.S.A.

Surgeon to the Honourable Trinity Corporation and Surgeon to the East and West India Dock Company.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—For the last two or three years he has heard no complaints as to the bad state of the river, but, prior to that, there were complaints. In hot weather he has noticed sometimes a little bad smell from the river, both on it and on the banks towards Blackwall; occasionally he has to go on the river, 15,432–8. Forty years ago reeds and rushes grew on the banks of the Thames and up the River Lea, but they have entirely disappeared. In 1849 he remembers taking home 50 specimens of plants growing upon the banks of the Lea in the immediate neighbourhood of the Thames, jnst above the Trinity Wharf. He can give no opinion as to what caused the death of the plants, but the river was in a bad state from the London sewage before the outfalls were opened. He noticed it when crossing the river on his way to Greenwich, 15,481–90.

Scientific Evidence as to the Deposit and Accumulation of Foul Mud in the Neighbourhood of the Main Outfalls.—For the last few years there has been a denudation of mud on the side of the river. As a boy he remembers the shore round the Isle of Dogs and opposite East Greenwich was very muddy, with reeds and rushes growing in it, but since the introduction of small tugs, principally, the mud has gradually washed away, leaving most parts clean to the gravel. In consequence there has been an increase of matter in suspension in the river, but during the last two or three years the water has been much clearer than it used to be. He thinks a good deal of the mud in suspension has either settled down, forming mud shoals, or else found its way out of the river, 15,455–60, 15,491–3. He has not noticed any smell from the mud near the entrance to the docks lately, nor has he heard any complaints from the men, though there were a good many complaints two or three years ago. The smell referred to by Captain Hussey might have been caused by letting the river water into the docks through the sluices, which would stir up the mud and so cause the smell complained of. This would probably pass off when the water became quiescent, and so he would not notice it, 15,494–5.

Effect upon Health in the Neighbourhood of the Main Outfalls.—He has been surgeon to the Trinity Corporation for more than 20 years, and has lived near the river all his life. He now lives at Poplar, 15,403–6. The Trinity Corporation has a wharf at Bow Creek, where the Lea joins the Thames, and it faces both rivers. The Trinity men are employed mostly in lighthouses and on board the light-vessels in the London district. Those on the light-vessels are kept two months on board, and then take a month's duty at the wharf. When on shore, they sleep in their own houses in the neighbourhood of Blackwall and Poplar, the majority of them living within half a mile of the Thames, 15,407–14, 15,461–72. There are about 200 men so employed, he believes, and they have very good average health. He attends their families in his private capacity as a medical man, 15,415–17. He has not been able to attribute any illness to emanations from the river, and he does not think they have suffered at all from zymotic diseases. The superintendent, who lives on the wharf, had an outbreak of scarlet fever amongst his children, but it was attributable to the defective drainage of the house itself, which has been pulled down, and another house built. None of the men employed on the wharf were attacked with scarlet fever, 15,418–24. There is a hulk lying off the wharf on which two men live, but there has been no zymotic disease on board. He would know if any case broke out, because he attends all the men. They are constantly going to and from the Trinity steamers in boats, 15,425–31, 15,473–4. He has also between 700 and 800 labourers employed by the East and West India Dock Company under his care, and they all reside in his district. These men work at the docks all day, and sometimes all night. There has been no prevalence of zymotic diseases amongst them, and although there have been 31 deaths in six years amongst these 700 or 800 men, not one was from zymotic disease. No case could arise without his knowing it, and it would not be removed to a hospital without his order. The superintendent and storekeeper, with their families, sleep on the premises, 15,439–50, 15,496–500. There may be a few more deaths which take place in hospital from accidents. A few men might be attended by a club doctor, but there are not many, 15,450–1. His house is about a quarter of a mile from the river, and he was born close to where he lives. He has never suffered in health from any bad emanation from the river, 15,452–4. The men employed in lighthouses are changed every month, and work at the wharf when on shore, sending stores, &c., all round the coast. Some are also employed in the Trinity steamers. The light-ship men for the greater part of the year are in good fresh air at sea. He examines the men and certifies them to be fit for the service before they are engaged, 15,461–72. The dock labourers belong to a provident society, to which he is the medical attendant, and he examines them before they are engaged by the dock company. He keeps a record in his diary of all the diseases the men are suffering from, but he makes no report, 15,473–80. All the men (Trinity and dock) are at work from eight in the morning in summer, and nine in the winter, until 4 p.m., nominally, but it is frequently six o'clock before they leave. In fact, from sunrise to sunset they are at work, except the gatemen, who have to take in vessels day and night. They are at their posts for about four hours each tide, 15,496–500. These men mostly live within two miles of the river, though scattered about; he practises generally in the neighbourhood, but the people are very healthy about Poplar, 15,501–4.

## MR. WALTER DICKSON, R.N.

Medical Inspector of Her Majesty's Customs.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He has held his present appointment 21 years, and occasionally he has noticed offensive smells coming from the river, but very rarely. There is a mud bank in front of the Custom House quay, which sometimes smells in hot weather, and in other parts of the river he has noticed an unpleasant smell when the mud has been stirred up by steamers. The river has considerably improved both as to smell and appearance during the last 10 years as compared with the preceding period. He seldom goes farther down the river than the East India Docks. If he goes to Gravesend, he travels by train. He has made inquiries from the Customs officials, and they say there is no great nuisance experienced from the river by the people on board the ships, 15,537–45. His predecessor, Dr. McWilliam, called special attention to the foul state of the river and the docks in June 1859. They began to smell most offensively, and serious apprehensions were entertained for the public health, 15,529–30, 15,548–51. He has ascertained that the smells which are noticed now at the Custom House are due to Billingsgate market, 15,549.

Effect upon Health in the Neighbourhood of the Main Outfalls.—Part of his duty is to supervise the health of the subaltern custom house officers of the port of London, consisting of about 1,000 men. The time these men are on duty varies from eight to 12 hours during the day, but many have night and Sunday duty as well, when they board ships at Gravesend, for then they have to remain on board until the cargo is discharged. The night duty may be said to be entirely on the river, and about 500 men are engaged in it, 15,505–10, 15,512. About three-fourths of the whole number are employed on or upon the margin of the river. Then a section of the men are called watermen, and these are very much on the river, their duty being to "rummage" ships for contraband or smuggled goods. All these men have very laborious duties to perform, and are much exposed to the weather and to changes of temperature, 15,511–15. Considering the nature of their duties, the health of the men is remarkably good. Eliminating accidents, the proportion of sick is about 3½ per cent. Zymotic diseases are almost unknown amongst them. There were two fatal cases of cholera within the last 26 years, and they were sporadic. One was due to great fatigue during the great fire at London Bridge in 1861, and the other was in 1866, when cholera was epidemic in London. This case was self-induced. The man was in perfect health and took medicine, which brought on profuse purging and turned to cholera, 15,516–26. About 250 of the men live at Gravesend, and their health is very good, as, in fact, is the health of the whole body

MR. WALTER DICKSON—*continued.*

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS—*continued.*

of men. He has never been able to trace any case of zymotic disease originating or caused by the condition of the river. He would know of any such cases, because the men cannot be withdrawn from duty without his knowing it. They are treated most liberally, and have every encouragement to apply to him. Pay during sickness is allowed for six months without any stoppage, the men are treated free, and have medicine supplied to them, 15,521–28, 15,535. He used to cross the river in boats, but has discontinued the practice owing to the danger on account of steamers. He is not much on the river now, 15,531–2. Except at Gravesend, the men's residences are widely scattered over the suburbs, 15,533–4. In 1858 and 1859, when the river was in such a foul condition, his predecessor reported that diarrhœa was not more prevalent than in any other year, 15,536. In 1859 there was less sickness amongst the men than in 1858, when the river was not so offensive, 15,550–1. He has made reports of a very similar character, going minutely into the effect of seasons, &c., upon the health of the men. A cold winter is the most injurious factor of disease, 15,552–3.

## MR. WILLIAM JOSEPH DIBDIN, F.C.S., F. Inst. C.

Chemical Assistant to the Metropolitan Board of Works.

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—For five years he was assistant to the late Mr. Keates, and at his death he succeeded him as chemical assistant to the Metropolitan Board of Works, 15,554–7. He made a series of investigations as to the condition of the river, especially with respect to the effect produced upon the water by the sewage which is introduced into it from the Metropolitan Board's outfalls. All the analyses he has made are recorded in a book which will shortly be handed in, and a further series will be handed in by Dr. Dupré, 15,558–61. The first series was made during the first three months of 1878, the second series was made in October and November 1878 in consequence of the "Princess Alice" disaster, and in 1880 the investigations were renewed. In making these analyses, he wished to ascertain whether the river water was impregnated with sewage to such an extent as to be injurious to the health of those travelling on the river or living in its neighbourhood, 15,562–4. He adopted Wanklyn's ammonia process, which is a delicate and trustworthy mode of ascertaining the amount of impurity in the water. It is the best he knows, and is used by Professor Way. It gives the relative, not the absolute, amount of organic matter, 15,565–9, 15,727–8. A number of samples of sewage were taken at Barking and Crossness from the sewers as it flowed into the reservoirs, at intervals of four hours over the 24 hours, at each outfall. He obtained 184 samples, and the average quantity of albuminoid ammonia per gallon of London sewage in the series of samples is equal to ·383 of a grain per gallon. Some contained a much higher quantity, others much less. The samples from the north and south are separate. The details of those analyses he hands in. (*See* Appendices B.X. and B.Y.), 15,570–8, 15,736, 15,818–35. He used the ordinary Thames filtered water as supplied by the water companies, which contains ·005 of a grain of albuminoid ammonia per gallon, 15,579–80. He then took a number of samples of water from the river during the months of March, April, and May, every four hours at first, and subsequently at hours varied so as to follow the tide, by which means he was able to get an absolute average of the quantity of putrescible matter in the sewage itself. The water samples were taken in the line of the sewage itself, and on each side of it, 15,581–9, 15,867–75. The details of these analyses are given in Diagram No. 1, and on page 11, Nos. 203 to 206, in the Tables, 15,590. On the 15th October 1878 the amount of albuminoid ammonia on the shore side of the line of junction of sewage and river water was ·254, and on the mid-stream side it was ·067. On the 11th August 1880 the amounts were ·207 and ·027 respectively. These two last samples were taken from the bow and stern of the boat, which was drifting at right angles to and in the stream of sewage. There was no special reason for the selection of these dates, 15,591–6. The samples taken in 1878 were taken in consequence of the complaints as to the state of the river at the time of the

MR. WILLIAM JOSEPH DIBDIN—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

"Princess Alice" disaster in the previous month, 15,597–9. Diagram No. 2 shows diagrammatically the analyses which are given in Table No. 5, Nos. 207 to 225. Four series of samples were collected in the line of sewage flowing from the northern outfall. The object of the diagram is to show the decrease in the quantity of albuminoid ammonia, yielded by samples collected in the line of sewage flow from the northern outfall on the 15th October 1878, the 13th March 1882, and 11th August 1882. The samples taken on the surface and near the bed of the river show very little difference, showing that the diffusion of the sewage and river water is complete, 15,600–7, 15,876–8. With respect to suspended matter, there is no doubt that the heavier portions, such as sand, would have a tendency to deposit, and therefore the amount of solid matter found in the samples would be greater in those taken near the bed of the river than near the surface, but the suspended matter in the sewage is very much lighter, about half the gravity of the river suspended matter, and the uniformity he referred to refers to the solubility of the albuminoid ammonia. In making his analyses, he allowed the suspended matter to settle, and examined the clear water; in many cases the suspended matter was examined separately. The amount of chlorine increases as the sewage decreases, but the chlorine is not the same at different depths; there is, however, a very close accordance. For example, on the 11th August, at the surface, the chlorine immediately off the outfall was only 40 grains, and 3 ft. from the bottom there were 138 grains; below Barking Creek, at Lawes' chemical works, the chlorine was 361 and 394 grains at the surface and bed of the river respectively, while at the Powder Magazine there were 392 and 398 grains, showing that the mixture was still more complete. At Crossness the difference was slightly greater. There is always an excess of chlorine at the bottom independently of sewage, but a few hundred yards from the outfalls the chlorine is tolerably constant, 15,608–14, 15876–8. The quantity of albuminoid ammonia may be taken as an index of the quantity of putrescible organic matter which is present in the sewage. He is speaking of "sewage" when it is in such a condition that it yields on analysis a certain quantity of albuminoid ammonia. When it no longer yields it, he speaks of it as water, 15,615–21. His object in putting forward the tables is to show what the sewage is in its pure state, and what it becomes when it is poured into the river. By putrefaction and oxidation it undergoes a very rapid change; as the putrescible matter decreases, so the albuminoid ammonia decreases, 15,622–36. The samples were collected in the line of sewage flow from the northern outfall, which is plainly distinguished from the river water as far as False Point, but beyond that, owing to the particular configuration of the river, the sewage is distributed over the whole width of the river. Occasionally it can be seen plainly further down, 15,637–41. Diagram No. 3 shows the amount of albuminoid ammonia yielded by samples collected in the line of sewage flow from the Crossness outfall on the 15th March 1882. It will be seen that the albuminoid ammonia decreased in quantity from ·336 grains per gallon down to ·028 grains per gallon at Jenningtree Point, 15,642–3. Diagram No. 5 shows the quantity of albuminoid ammonia in a number of samples which were taken off Woolwich Arsenal at high-water and one hour after high-water from the 10th August 1880 to the 18th October 1880. The amount of chlorine is also shown, which gives a rough idea of the proportion of fresh and sea-water. The analyses for chlorine and albuminoid ammonia were taken from the same sample. The maximum of albuminoid ammonia was ·042 on the 12th October, and the minimum was only ·021 on the 12th August and the 23rd September. When the chlorine rises it indicates that the proportion of sea-water coming past the outfalls is greater than the water coming down from above, and when it falls the land-water is greater, and the pollution also is greater, indicating thereby that the main causes of pollution are rather to be sought above Woolwich than below. It is curious that when the albuminoid ammonia was at its maximum the chlorine was at its minimum, showing that the floods had reduced the proportion of sea-water to an abnormal extent, 15,644–65, 15,860–3, 15,879–88. Diagram No. 6 represents a series of samples taken off Woolwich Arsenal an hour before high water from the

MR. WILLIAM JOSEPH DIBDIN—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

15th August to the 5th December 1881, and the analyses are given on Table 3, Nos. 95 to 102. The red line represents the mid-stream sample, and the blue line the sample vertically over low-water mark. There is less pollution in the mid-stream samples than in those near the shore. The curve represents the relative amount of the organic ammonia. The same tendency is shown here as in the case of the other samples, viz., the lower the chlorine, the higher the pollution, 15,666–73, 15,879–88. Some samples taken in October 1880, and in November and December 1881, are some prominent instances indicating that the water at Woolwich is largely affected by some source of contamination above Woolwich which he is unable to explain. The mean quantity of albuminoid ammonia off Woolwich from samples taken in 1878, 1880, 1881, 1882, and 1883 respectively, was ·0317, ·0286, ·0373, ·0277, and ·030; the variation is very slight, but it is in favour of the present period, 15,674–5. Diagrams Nos. 7, 8, and 9, represent the amount of albuminoid ammonia found in samples collected at half-flood and half-ebb upon the surface of the water and two feet above the bed of the river on the 27th July and 3rd August 1882, at Blackwall, Woolwich, Barking Creek, and Erith. From the result of these analyses there is no very great difference between the top and bottom of the water, and the only conclusion to be drawn from them is that the mixture is complete, 15,676–7, 15,901–8, 15,910–12. On the 24th August 1882, samples were collected during three-quarters ebb, 200 yards from either shore, and in mid-stream off Crossness Point and Erith Causeway, to ascertain whether there was any difference in the water. The result shows that it was the same on either shore at Crossness Point, and rather better in mid-stream, and at Erith the mid-stream was still the best, but the variations are very slight. Diagram No. 10 gives these results, 15,677*a*. Diagram No. 4 shows the samples taken upon the 31st August and 1st September 1882, at all periods of the tide. On the 31st at low tide the river, having received the sewage, was at its worst, it was improved two hours later by the water from below, at high water it was at its best, and became worse again at quarter-ebb. On the 1st September, after having been scoured by the very high tides of the preceding day, the river was a trifle worse at half-ebb than it was at a corresponding time on the 31st; it was about the same at three-quarters ebb, and considerably better at low-water, notwithstanding the sewage; but at high-water the impurity increased to a maximum for the day. From all these analyses, speaking generally, it is manifest that the organic pollution of the Thames for the six years over which they extend is practically constant, and not an increasing quantity. The figures at Woolwich with slight variations would apply to any other portions of the river, but the average result of it all is that it is very much the same during the period of six years, 15,678–82, 15,879–94. The various analyses show that the organic ammonia yielded by samples collected above Teddington Weir is only from half to a third of that in samples taken at Woolwich; so, if the additional quantity of organic matter which the river receives in its downward course from the shipping, &c., be deducted, it will be seen at once that, if the water at Woolwich and other points in the neighbourhood of the outfalls is contaminated by the Board's sewage works, it can only be to a trifling extent, not greater than that present in ordinary London drinking water, 15,683–91. Table No. 5 gives the analyses of some samples in the Victoria Docks, Deptford, Bow, and Barking Creeks. The water in these places is worse on the whole than the water in the Thames in mid-channel. He will furnish the exact spots where the samples were taken. He has taken other samples (or they have been taken for him), but he can prove the collection of all the samples in his tables, 15,692–702, 15,716–26. Some doubt having been cast on a sample taken in the Victoria Docks in 1878, he had a sample collected yesterday morning at 8.30 a.m., 100 yards inside the inner lock, 20 minutes before the gates were opened, so it may be accepted as a fair sample of the dock water. It contained ·059 grains of albumenoid ammonia and 150 grains of chlorine per gallon, while the 1878 sample contained ·066 grains of albuminoid ammonia. This proves that the water in the Victoria Docks contains more than twice as much nitrogenous organic matter than the general average of Thames water in mid-stream in the neighbourhood of the outfalls, say from Woolwich to Erith. The docks no doubt contain



MR. WILLIAM JOSEPH DIBDIN—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

impurities from the shipping, 15,705–15. He has compared the water in the Thames with the water in the Victoria Docks, and goes through his tables, showing the quantity of albuminoid ammonia and chlorine each sample contains, 15,716–26. He thinks he can show by his own evidence, and that which is to follow, that the albuminoid process is a very reliable test not only for sewage but is a guide used almost universally by chemists as a test of the quality of ordinary drinking water, not only in England, but elsewhere, as an indication of relative purity, 15,727. It is found in almost every sample of water, even in distilled water a trace can be found, 15,728. There are several other methods for estimating the quantity of organic carbon and organic nitrogen, for example, the permanganate process, but when a mixture of river water, sea water, sewage, &c., is to be dealt with he knows of no better method than the albuminoid process, 15,729–30. He has not compared his results with those of Professor Heaton, because their methods of operation were different; Professor Heaton included a great quantity of suspended matter in his albuminoid ammonia, while he allowed the suspended matter to settle and then drew off the water. His figures, roughly speaking, correspond with Professor Way's, though the results are given in parts per 1000,00, and his in grains per gallon, 15,731–6. On page 13 of the Tables Nos. 246, *et seq.*, a number of analyses are given of sewage from sources other than the Metropolitan Board's outfalls. The average results are given on page 6, 15,736. It will be remembered that the other side stated that the average quantity of suspended matter in sewage, taking wet and dry weather together, was nearly 50 grains per gallon, and there was some controversy about it. To settle the question, he had a series of samples taken in March, April, and May 1883, and the average quantity of suspended matter amounts to 27·39 grains per gallon, which makes a material difference as to the quantity of solid matter discharged into the river, 15,736. On the 16th August 1882 he noticed a discharge of sewage into the river at Chiswick, and obtained a sample of sewage and water, as he could not get a sample of the pure sewage, and on analysis it yielded ·31 grains of albuminoid ammonia, which is nearly equal to the amount at the Board's outfalls. It is not surprising, therefore, that sewage is should have been *traced* as high as Chiswick, 15,737. At Beckton Gas Works and at Erith a considerable quantity of sewage is discharged into the river The discharge on to the foreshore from the Erith outfalls was far more foul than anything coming from the Board's outfalls, and when exposed to a hot sun would give off most offensive odours. A sample taken yielded 3·70 grains per gallon of albuminoid ammonia, and the odour from that sample was the worst he ever analysed. He has also seen lying on the beach at Erith slaughter-house refuse of all kinds, solid sewage, and other matters, and although the day was comparatively cool, the atmosphere was exceedingly obnoxious, and is quite enough to account for the smells which have been so much complained of at low-water, 15,738–44, 15,916–21. He has for the last six years made a number of chlorine determinations all over the Thames, but in no case has he found it ever exceed 5 grains per gallon at London Bridge. He twice obtained 4 grains, but it was on occasions of exceedingly high tides. The inference he draws from that is that the quantity of sea water at London Bridge is very minute, 15,745–6. He has inspected the river upon a number of occasions, and has taken some pains to ascertain the temperature of the water between Greenwich and Erith, and although it has sometimes been nearly 70 degrees, the odour from the water has not differed from the water at Teddington or Southend. When shaken up in a jar, he has noticed a "sedgy" odour, but never anything that would indicate sewage unless he has actually been in the line of the sewage. The smell from the factories is very strong, and he has never been down the river without smelling one or more of the factories according to the direction of the wind. At times this smell is extremely nauseous, and he can quite understand that the fishermen should have imagined them to come from the river, 15,771–2, 15,946–9. He has not heard that "Wanklyn's process" has been given up by a great number of chemists. It is a rapid and easy way of getting at a result, but it is not always reliable. A great many still use it, and possibly a great many do not. There are very few processes which give you the actual composition of the organic matter in a sample of water, but he thinks

Mr. WILLIAM JOSEPH DIBDIN—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

it is reliable enough to indicate the source from which the albuminoid ammonia comes, 15,775–82. Albuminoid ammonia is now taken as an index of the amount of putrescible organic matter, and what is likely to become putrescent. It only takes into account the nitrogen, not the carbon. A great deal of albuminoid ammonia comes from things which are not, nor are likely to become, putrescible. Some bodies yield half their nitrogen, some their whole nitrogen, as albuminoid ammonia, while others which have nitrogen yield no albuminoid ammonia at all, 15,783–90. He has never tried uric acid or urea for nitrogen which yields ammonia. There may be elements of pollution in the water which may yield no albuminoid ammonia, and there may be also a great deal of albuminoid ammonia which results from causes quite independent of sewage pollution, but in the case of the Thames he does not think there are, 15,791–8. Peat yields an enormous quantity of albuminoid ammonia, but he does not consider that its presence in the Thames is due to any other cause than sewage. The quantity varies considerably if the circumstances are not regarded, but if the state and time of the tide and the rainfall be considered, it does not vary capriciously, 15,799–811. He has tried the combustion process, but it is neither so simple, nor so quick, nor so reliable, as Wanklyn's process. He believes many chemists use the combustion process, but it is open to so many sources of error that it is hardly worth while adopting it, 15,812–17. Although he took 181 samples, one sample would have been sufficient to evolve his theory if he had obtained a mean sample, but if the sample is an exceptional one, the result would be fallacious. He found very great fluctuations in his results of albuminoid ammonia. His reason for mixing three samples together was to get fair average samples, as the strength of the sewage varied according as it was day or night sewage. It was never the same strength for eight hours together. It would, in addition, have required a very large staff of assistants to examine each sample separately. Page 7 in Volume 2 of the tables gives the strength of each sample separately, but he has not ascertained the quantity of albuminoid ammonia, as it would have occupied too much time to do this when 24 samples were collected each day, 15,818–34. A considerable quantity of rain fell, as he shows on page 7, during the time the samples were being collected, 15,835. The samples in 1878 were taken to test the accuracy of Captain Calvert's statements as to the condition of the river, and those samples which he analysed personally are entered in Table I. Many others were taken and analysed by other people. The number he took was 22, and the samples are spread over the whole of the year and in different places. The state of the tide is given in most cases, and he supplies the deficiencies now, 15,846–58. He selected Woolwich as his place to make the observations recorded in Table 2, because many complaints were made as to the state of the river then. The deduction he draws from page 3 at Woolwich is that the contamination of the river at that point is so small as to be immaterial to the question of its giving forth emanations which are likely to be injurious to health, 15,859–61. By taking high-water and an hour after high-water, which is the water from below the outfalls, one would expect it to be the horrid polluting stuff that it is said to be, but the figures show that it is not so, and that at high-water on 13 days out of 20 the samples contain the least pollution when they ought to contain the most sewage, 15,862–6. As a rule, the chlorine increases with the spring tides, which is at the time of the full moon. On the 16th, 19th, and 20th August, when the tides were approaching spring tides, there was a depression of chlorine, 15,897–900. At Barking Creek the amount of albuminoid ammonia at half-ebb and half-flood is about the same, but above Barking the half-flood is worse than the half-ebb. The difference, however, only amounts to ·0020, which is not so much albuminoid ammonia as is found in London drinking water, and, therefore, is of no moment, 15,901–5. The samples on which his Volume 1 is founded are single samples, not taken across the river, except the Erith ones, which were taken at three different points across the river. These were taken at the surface, and halfway down, so there were six samples which he mixed in order to get a fair example of the condition of the river 15,909. The mixture of sewage and sea water turns the sulphates into sulphides. The organic matter

Mr. WILLIAM JOSEPH DIBDIN—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

and the sulphates react upon one another, and sulphides are formed. Then the ferruginous clay which is suspended in the river water acts as a purifying agent by absorbing the sulphuretted hydrogen so formed, and in that way the black colour of the mud is obtained. Sulphuretted hydrogen is not given off, because it is immediately seized by the clay in suspension, 15,913–15. He does not think the sulphuretted hydrogen is ever given off again, because oxidation is going on, and the iron is converted into oxide of iron, and the sulphur is set free, 15,925. He knows of no method of analysis that gives certain absolute indications as to the source of the organic matter present in the deposit; they are all relative. Albuminoid ammonia, which he took for comparison with sewage, yields a certain standard quantity, and albuminoid ammonia may be found where there is no sewage, but not on the Thames to any appreciable extent, 15,922–4. Ammonia would be got as free ammonia from the urine in the water; but if Wanklyn's instructions for analysis were carried out, it would all be destroyed in the preliminary boiling, 15,926. There is a large amount of vegetable matter in the Thames, and a certain amount of albuminoid ammonia is derived from peat at Teddington, but he should not consider it a peaty river, and it is well known that there is a considerable quantity of sewage discharge into the river above Teddington, 15,927–8. He does not know that anything is given off from the sewage in the river to cause the smell; you smell it, as it were, like the smell of a rose, for example. It ceases to smell when the matters which give rise to that odour are destroyed either by oxidation or other cause. It is destroyed as sewage, though the materials remain, and the carbon of which a part of the sewage consists is converted into carbonic acid gas. That would be dissolved in the river water, and probably unite with lime or other substances to form carbonate of lime or chalk. Some, no doubt, would go into the atmosphere if the water was overcharged with it. The ammonia would in part be lost by evaporation, and in part be converted into nitric acid, and combine with the alkaline salts which are found in the river to form nitrates. The solid parts of the fæces which are soluble would enter into solution with the river water and go out to sea, and the insoluble portions would be held in suspension and carried away with the other suspended matter; and, as the specific gravity of sewage is little more than half that of the river suspended matter, it is reasonable to suppose that, if the latter is carried out to sea, the sewage would also. The heavier portion, such as sand, &c., would be deposited if an opportunity was given to it, 15,929–45, 15,954. The sewage when first discharged from the outfalls smells, and the smell can be detected on a calm day, when in a boat on the river, for 600 or 700 yards; but on a cold, windy day, with the water a little rough, the smell disappears in an astonishing short time. There is no smell on the return of the tide, for the sewage has then mixed with the water and is lost, 15,946–9. Water, when it has lost its due proportion of oxygen, does not become fœtid or objectionable, because it rapidly re-absorbs oxygen from the atmosphere. It could be drunk without injury, if it contained nothing injurious to health, when deprived of its oxygen; but the very fact of its absorbing oxygen shows that the water had contained matter which ought not to be present in drinking water. At Gravesend, he thinks, there is a little sewage still unoxidised, 15,955–62. He has dealt in the albuminoid ammonia estimations with that quantity of impurity which is in solution both in the sewage and in the river water, and that quantity, he considers, is the most important. The average amount of suspended matter in the sewage he has shown to be equal to 27·29 grains per gallon, and the sewage is discharged into over 200 times its bulk of river water, and the mixture is complete. He has not dealt with the suspended matter and the question of its disappearance, as that has been considered by others who will give evidence on the subject. He has only dealt with the matter in solution, 15,963–5. With regard to the fact that fish cannot be kept alive in the wells of fishing boats above Gravesend, he attributes it to the absorption by the sewage of the oxygen in the water, and so rendering the water in a condition which is not fit for sustaining the life of a fish. They require oxygen for breathing just as much as human beings do, and without it they suffocate. Indirectly it is due to the sewage, but not directly, 15,950–3.

## Mr. WILLIAM JOSEPH DIBDIN—*continued.*

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—The results of his analyses, as regards suspended matter in the London sewage, are given in Volume 2, which he has laid before the Commission, and the total quantity of suspended matter in the London sewage in April and May 1883 is equal to 27 · 39 grains per gallon. He has taken the effect of the rainfall into consideration, and it is shown in the tables. The samples were taken every four hours. At Barking a sample was taken from the lip of each of the three outfall sewers, and then they were mixed together. At Crossness the samples were taken just as it came from the pumps, so that it was thoroughly mixed. He thinks it represents the average as nearly as it could be obtained, 15,747–53, 15,836–45. He has taken samples of mud from the various banks in the neighbourhood of the outfalls in 1883 as nearly as possible in the spots where samples were taken in 1879, and he also analysed them in the same manner. He finds generally that there is no practical difference whatever in the composition of the mud. He has not made any comparison with the mud near the outfalls, and that mud which is not subject to the influence of the outfalls, as the matter was gone into so thoroughly at the time of the Mud Inquiry, 15,754-9. At Erith the mud six inches below the surface is the same as the ordinary Thames mud, but, when skimmed off the surface, it contains rather more organic matter than it does below. The quantity of organic matter in the sewage mud from the floor of the reservoir is 34 · 68 per cent., and the surface sample at Erith Pier contains 14 · 28 per cent.; but the nitrogen in the organic matter in the sewage mud is only 5 · 34 per cent. against 4 · 69 per cent. in the Erith mud, 15,760–4. The organic matter in the mud of the River Fitzroy in Queensland, which is totally free from all sewage contamination, contains nearly as much organic matter as the Thames mud, 15,765–70, 15,773–4. A reference to his tables will show that a good deal of rain fell when he took his samples of suspended matter, and therefore the average of 27 · 20 grains per gallon cannot be considered a dry weather average. In order to obtain the average, there must be samples containing a considerably greater and lesser amount of suspended matter than 27 grains. The highest quantity in his tables is 76 grains, and the lowest 10 · 5 grains; but under exceptional circumstances, such as a heavy storm of rain and hail, as much as 100 grains, or even 146 grains, of suspended matter may be found in the water. He considers 76 grains an exceptionally high sample, but it is the average for 12 hours. Had he taken a sample every hour for 24 hours on that occasion, the result probably would have been higher, 15,836–45.

## Mr. AUGUST DUPRÉ, Ph.D., F.R.S.

Lecturer on Chemistry at the Westminster Hospital.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—In 1857 or 1858, in conjunction with Dr. Odling, he was engaged in making analyses of samples of water taken principally at Greenwich, and also at Lambeth and higher up the river. The analyses are not of a character to be compared with the present analyses, but they gave certain indications of the condition of the water, and they brought out Mr. Baldwin Latham's mixing action very clearly. They showed that as the tide flows up, the salt water goes up the centre of the river, and when running down the salt water goes down the sides, and the fresh water down the middle. No comparison can be made between the two analyses as to the purity of the river, as it is infinitely better now above Greenwich, 15,970. The average amount of suspended matter at Greenwich in 1857 and in 1882 between June and September is as follows:—

| Year. | High Water. | Low Water. |
|---|---|---|
| | Grains per gallon. | Grains per gallon. |
| 1857 - | 2·43 | 4·57 |
| 1882 - | 4·05 | 3·93 |

The mean in the two years is very nearly the same, 15,976, 15,986–7.

## Mr. AUGUST DUPRÉ—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

At Greenwich the volatile matter, which indicates organic origin, in 1857 at high and low-water respectively was 35·39 per cent., and 26·45 per cent. when the sewage was discharged above, while in 1882, when the sewage is discharged at Barking, the volatile matter amounts to 24·9 per cent at high-water and 20·20 per cent. at low-water, showing that the suspended matter of the river contains a smaller percentage of organic matter now than it did 25 years ago. By volatile matter he means that which would pass off by ignition as distinguished from mineral matter, 15,977–85. At Woolwich the volatile matter is less at high-water than at low-water at the present time, 15,987–90. There are three methods now usually adopted by chemists for estimating the relative quantity of organic impurity in water. None give the absolute quantity, but general conclusions can be drawn. The permanganate process is the oldest, and although Dr. Tidy stated it was not applicable to the Thames where there was sea water, and had therefore abandoned it, he considers that, if it is properly worked, using a close instead of an open vessel, it gives equally good results in salt water as it does in fresh water, and he has adopted this process all through the river. The principle consists in estimating the amount of oxygen which the water takes from the permanganate, 15,991–2, 16,139–54. The second method is known as the albuminoid ammonia or Wanklyn's process, which estimates the amount of ammonia evolved when boiled with an alkaline solution of permanganate. From this process only comparative, but yet good, results can be obtained, 15,993–4, 16,139–54. The third method is that of Professors Frankland and Armstrong to estimate the organic carbon and the organic nitrogen; but this only gives relative results, and in the case of the Thames it is not applicable, because sea water gives very much organic carbon and organic nitrogen, so that the organic matter in sea water is fouler than in sewage if this process is taken as a guide, whereas the two other processes show the sea water to be pure, and they are the more reliable processes, 15,995–8, 16,139–54. London sewage in 1882 contains on an average, from analysis, 12 grains of chlorine per gallon; it yields 0·44 of albuminoid ammonia; it absorbs 2·80 grains of oxygen from permanganate, and holds about 25 grains of matter in suspension. The suspended matter contains 64·50 per cent. of volatile matter, and 35·50 per cent. of mineral matter. The volatile matter contains 5·75 per cent. of nitrogen, 15,999–16,001. The amount of solid matter per head that goes into the sewers is, fæces one ounce and urine 1·68 ounces, that is, when dried at 212 degrees. Of this 1·68 ounces, roughly speaking, half is urea, which is all converted into carbonate of ammonia before it reaches the river. Of the remainder, one-fifteenth is organic matter, and the rest is mineral, chiefly chloride of sodium. Some of the samples were taken from the outfall sewers as they flowed into the reservoirs, but these contained no urea, 16,002–6, 16,179–96, 16,223–6. From the one ounce of fæces ·14 of an ounce is mineral matter, so the total amount of organic matter per head of population which actually goes to pollute the river is only ·916 of an ounce, which, taking the population at 4,000,000, gives about 100 tons a day, or 36,500 tons a year, instead of "400 tons of filth," as estimated by Dr. Tidy. The amount of oxygen necessary to oxidise this amount would not be more than 200 tons, 16,007–8, 16,179–96, 16,223–6. There is generally more or less turbidity in the river all the way from Teddington to Southend. The amount of suspended matter varies very much, even in the same place, and it is sometimes worse at Teddington than it is at Crossness, even as regards nitrogen. In sewage the suspended matter is 25 grains to the gallon, and in ordinary water the average varies from one to ten or twelve grains, 16,009–22, 16,024. The samples he took in July 1882 and January 1883 show upon the whole that the suspended matter contained less volatile matter than in the earlier years. He hands in a bound copy of his analyses, *see* Appendix B.Z., 16,023–4. He hands in a table giving the amount of suspended matter and the percentage of volatile matter in the suspended matter in the water at Teddington, Kew Bridge, Westminster and London Bridges, Greenwich, Crossness, Erith, Greenhithe, Gravesend, and Yantlet Creek, in 1878 and 1882. The samples were taken in mid-stream at each place every hour during one day, on the surface, half depth, and

Mr. AUGUST DUPRÉ—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

bottom. Each result is therefore the mean of 37 estimations. He also hands in a table giving the mean results obtained between July 1882 and January 1883 at various places in the river between Teddington and Southend, 16,009–24, 16,197–202. He also hands in Table B., which gives the amount of suspended matter in Thames water, 16,024–6. The book of tables he handed in show the basis upon which the deductions are drawn; the details occupy the pages from 1 to 102, and the mean results from page 103 onwards, 16,027–8. The first table deals with oxygen absorbed from permanganate. Table 2 B. and Diagram 2 B. give the same results. At Teddington the river contains a small proportion of impurity, and rises gradually to more than twice the quantity at Greenwich, and then falls to less than the original quantity when Southend is reached. By the time Coalhaven or Northfleet is reached, the river has done its work, and has destroyed the putrescible constituents of the sewage, and the water is restored to an equal condition of purity to what it had when it entered the tidal section of the river. In the neighbourhood of the bridges there is a curious increase of pollution. On the average the river at Blackwall is not more impure than elsewhere except at high and low-water, when the increase of impurity is most marked in the neighbourhood of the outfalls. Diagram 2 B. and Table 2 B. give the mean results for July, August, and September, 1882, 16,029–35. Table 2 C. gives the mean results for high and low-water in January, March, and May, 1882. In the upper part of the river the condition is about the same at high and low-water, while in the lower reaches it is worse at low-water than at high. In July, August, and September, 1882, the river is worse at high-water in the upper part, and better at low-water in the lower reaches, 16,036–40. Diagram 2 F. shows that, if anything, the river is a little purer in 1883 than in 1882, provided the amount of fresh water is the same at each period. But the river is so frequently flushed out that it does not get progressively more foul, 16,041–2, 16,212–17. The next series of diagrams, beginning at page 108, deals with the albuminoid ammonia. Diagram 3 F. shows the results of the analyses in 1878, 1882, and 1883, and the year 1883 is the best throughout. The river is worst at Deptford Creek at high-water, and at Greenhithe at low-water, 16,043–59, 16,203. The last series of diagrams, beginning with No. 4 B., deal with the amount of free oxygen remaining dissolved in the water. If the amount of pollution is very minute, the absorption of the oxygen from the air would prevent any reduction in the amount of free oxygen; but if the polluting matter be introduced into the river more rapidly than the air will supply oxygen, the free oxygen in the water will then diminish, that diminution being the measure of the amount of oxidation of putrescible matter which has gone on, 16,060–3. He has assumed the percentage of free oxygen in the water at Teddington to be 100, and in the diagrams, according to that scale, he has indicated the percentage of the full quantity of free oxygen which was still left in the water which he finds at different places, 16,064–5, 16,173–8. He does not agree with Dr. Tidy's view that the fact of the oxygen having fallen below the standard amount is an indication that the river has lost its power of oxidation. It is an entirely erroneous statement. (*See* Questions 9957–63.) [*Dr. Tidy intimated at this point that he never suggested anything of the kind.*] 16,066–9. Diagram No. 4 B. shows the analysis of the water, made on the spot, between Teddington and Southend. The samples were taken on one day in August and one day in September. Those taken on a day in November were for the purpose of comparison, and it shows that when the weather is cool less oxidation goes on in the water, corresponding to the fact that more organic matter was found in the water during the cooler than during the warmer months. The long curve on the diagram is made up from the samples on the two days only, and it will be seen on reference to Table 4 A., page 66, that the degree of aëration found at Westminster Bridge on the two dates differs but slightly, viz., 54·5 per cent. on August 9th at nearly high water, as against 48·6 per cent. on September 2nd at three-quarters flood, 16,069–72. Starting at Teddington with water thoroughly aërated, it diminishes until at the outfalls there is only 20 per cent. of the original oxygen, and then it rises again at Southend to 96 per cent. of

Mr. AUGUST DUPRÉ—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

oxygen. This is not due to abstraction of oxygen, but that salt water dissolves less oxygen than fresh water. The water is thoroughly aërated, but it is only 96 per cent. of what it would be in fresh water, owing to the proportion of salt water mixed with the fresh. The inference he draws from this is that the sewage from London has been disposed of before it reaches the lower part of the river. Mr. Dibdin's analyses do not go so far down the river as his. They do not extend below Purfleet. The water at Southend is undrinkable, being sea-water, 16,073–6, 16,173–8. At Erith the proportion of free oxygen at low water is at its minimum, or about 8 to 10 per cent. At high water it reaches the maximum, or upwards of 40 per cent. The eddies on the south shore cause the irregularities shown on the diagram. The comparison of the oxygen in the water at Erith at high and low water shows that the river here is beginning to overpower the polluting influence. As each gallon of water contains half a cubic inch of oxygen, he calculates that as much as 233 tons of oxygen pass up the river in one tide, or 466 tons in a day, which is in addition to the quantity in the water as it went down, and is more than enough to deal with the 100 tons of sewage. It is the absolute quantity (not the excess between 8 and 40 per cent.), and is based upon the mean quantity of 25 per cent., not upon the maximum observed, 16,077–93. Mr. Law has gone fully into the question of the chlorine, but he thinks the amount on the 14th September was exceptionally high. He has never obtained so high a result, 16,094. Taking the results of all these analyses, he thinks the river is quite capable of disposing of the sewage that is discharged into it, and that upon the average it is daily got rid of, otherwise there would be a progressive increase in the pollution, which he has not observed, but, on the contrary, the river is in a better condition now than it was five years ago, 16,095, 16,099, 16,212–17. The amount of pollution at Erith, for example, as indicated by his analyses, if added to the Teddington water, would represent 3 to 4 per cent. of pure sewage at low water, and at high water it would be less than one per cent., 16,096–8. The sewage is not all of it oxidised, a great part of it is disposed of by animal and vegetable life before it reaches Southend. The amount of infusorial life in the river in summer is something enormous, 16,100–2. Dr. Frankland stated that the river was getting worse progressively above the outfalls, but this is not the case, 16,103, 16,126, 16,127. During the months of July, August, and September, 1882, he was 17 days on the river. He noticed no offensive or disagreeable smell from the water, except when in the immediate neighbourhood of the outfalls; nor did he notice any in the spray thrown up by the screw of the steamer, which he followed for the purpose. When shaken up in a bottle, there was a faint peculiar musty odour like wet straw which is noticeable all the way down from Teddington, 16,104–7, 16,218–20. Some samples of the water were taken by Mr. Dibdin shortly after the "Princess Alice" accident, but he personally took no samples until November. He has frequently examined the water at that spot, but has never found it offensive. He was there several times during the hottest part of the summer, 16,107, 16,108. The actual stream of the sewage in hot weather is very offensive and very nauseating, but it is not a very powerful or penetrating smell, so that it is very soon lost. In ordinary weather the smell is lost in the actual sewage stream in about 1,000 yards, and it is lost in the river when in a boat within a few hundred yards. On the 16th June 1883 he was in the stream, and he never saw it so well defined before. It was visible 2,000 yards down the river because of the floating matter, not the sewage. The smell given off is carburetted hydrogen chiefly, but there are also some compound ammonias. It is a very complex mixture, but there was no smell 2,000 yards away. He has never before seen the line of demarcation between the sewage and the river beyond 500 or 600 yards, because the stream from Barking Creek comes into the river 200 yards below the outfall, and pushes the sewage into the centre of the river, 16,109–16, 16,227. The result of his analyses confirms his view that the sewage mixes very rapidly with the water of the river, and Dr. Tidy's Table No. 6 shows this very strongly indeed, 16,117–18. There are a great many smells from the factories on the banks of the river which are very penetrating and very

Mr. AUGUST DUPRÉ—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

offensive; sometimes they are so powerful as to be offensive 2,000 or 3,000 yards away. There is in addition a great deal of slaughter-house refuse and manure, and various offensive matters, such as rotten fish for making manure, which are carried on the river in barges, and the smell from these is sometimes really indescribably offensive, 16,119–21. He believes that Wanklyn's process when properly performed is fairly reliable, and that it and the oxygen process give as a rule analogous results. He would not like to say which was the more reliable method. 16,139–41. The analyses as shown in his tables by the oxygen test and the albuminoid ammonia test, broadly speaking, show the same results when the waters are pretty nearly equal, though sometimes different results are obtained when the water is tested by the two processes. Neither of the two processes profess to give the absolute amount of organic matter, they must be compared with themselves and not one with the other, otherwise there will be discordant results. If the oxygen process is compared right through to the end, and the albuminoid ammonia process compared also to the end, the conclusions will be found to be identical, 16,142–54. The diagrams he handed in are based in a general way upon a number of samples, varying from 20 to 3, and in a few cases only one sample. The table is a catalogue of every sample taken, and shows by the mean of the calculations how many samples were taken, and they are all arranged topographically, 16,154–63. Diagram 4 C. shows the percentage of free oxygen dissolved in the water off Erith Pier on the 31st August and 1st September 1882, and he thinks it is a very fair specimen. The days were not selected for any particular purpose, and he did not know that the tides would be exceptionally high. He was at leisure on those days, and accordingly went down the river. There is no doubt also that the river had been scoured out by the heavy rain, and with a high tide the amount of oxygen at high water is greater. The other days on which he took samples were rather unfavourable for the purpose of getting good results. He does not think the amount of albuminoid ammonia varied very much according to Mr. Dibdin's diagram, 16,164–72. Sea-water does not dissolve so much oxygen as fresh water. There is a difference of four per cent. between the two. The amount of oxygen in water varies greatly with the water, and no conclusion can be drawn unless the temperature of the water is given. This unfortunately has not been given by the other side, whereas in his tables it is always given, 16,173–8. He took Professor Law as his authority for stating that the amount of solid matter in the fæces was one ounce, and he thinks it is a very fair estimate. In Mr. Symon's book on Animal Chemistry the quantity of salts, according to Berzelius, varies largely, being as much as 15 or 20 per cent. in some cases, 16,179–88. As regards the amount of solids in urine, he took the figures 1·68 per cent. from Woolf and Lehmann. Liebig, who is an acknowledged authority on these matters, gives the total amount of "dust-dry" residue of the liquid and solid excrement of 1,000,000 people as 45,000,000 lbs. per year, which is somewhat less than two ounces per day. He takes it at 2·6 ounces, which is materially higher, 16,189–96. The water into which the sewage is discharged goes down with the ebb tide about 12 miles. The sewage can be detected to a very small extent at Purfleet by analysing the water, but it must be done very carefully. It cannot be detected by the smell. The presence of the sewage in the water would be shown by analysis to contain a little more albuminoid ammonia, and that it absorbed more oxygen from the permanganate than it would otherwise, so that the volatile matter would not have been destroyed entirely by the action of the oxygen in the water, 16,204–11, 16,227. From chemical experiment, and from ordinary observation extending over a number of years, he founds his statement that the river is not increasing in its pollution. He does not think that 1882 was an exceptionally cold and wet year. The Astronomer Royal's tables show that the temperature was nearly equal to the average, and that the rainfall was very little above the average, 16,212–17. He can distinguish between the sewage and factory smells when he is close to or actually in the sewage stream, 16,218–20. His samples, from which he draws the annual mean, were taken at random, and not on any particular day or in any particular month, so the

Mr. AUGUST DUPRÉ—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

results are not likely to be affected by any exceptional circumstances applying to a particular day, 16,221–2. The salt in the sewage is dissolved in the water, but it would be a very minute fraction compared to the salt which came in from the sea, 16,225–6. He believes that, if a person were blindfolded and taken down the river, he would be able to point out every foul factory to the windward, and every foul boat he passed, by his nose; but he would not know when he passed the outfalls, 16,227.

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls.—He has known the Thames for about 28 years, and for upwards of 20 years has had opportunities of observing the banks when shooting at Canvey Island, and, owing to the quantity and stickiness of mud, it was necessary to have boots extending up to the thigh. The mud was of a brown colour at the top and black underneath, 15,967–9. He has examined and analysed the mud from Teddington to Erith, and finds that it is very much the same all the way down. If there is a difference, the mud in the upper part of the river is slightly fouler than that in the lower portion of the river. For example, the worst mud bank in the river is at Westminster Bridge, on the Middlesex side, 16,122–5, 16,128–31, 16,229. He has never heard any complaints about it from the hospital, 16,132. He hands in Table C. which gives the results of an analysis of some samples of mud collected at Erith only. This shows that the Erith mud bank is practically of an identical composition with the mud banks up and down the river, which he analysed upon the occasion of the Mud Inquiry, and the results are given at page 1,065 in the evidence taken before that Commission. The greater number of the worst banks are to be found in the upper part of the river, 16,133–8.

## Sir FREDERICK ABEL, C.B., F.R.S.

Chemist to the War Department.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—The term "putrefaction" is what chemists call a "metamorphosis," a change in the arrangement of the components of a chemical compound of animal origin containing nitrogen, resulting in the production of a class of comparatively simple bodies some of which have very powerful odours indeed, and those produce what are known as putrifying smells or odours. Those bodies are transient in their character, and are eventually converted into the most simple products, which are, generally speaking, gaseous, and escape into the air in the ordinary course. "Burning up by oxygen" is a transformation which takes place under conditions of temperature and other conditions favourable to that change. There is no addition to the substance, 16,229–30. The analytical results in the form of tables, which were handed in by Dr. Dupré, are the joint work of that gentleman and himself. In a general way he agrees with the conclusions which have been drawn from them by Dr. Dupré, and he agrees with the views expressed by him as to the value of these methods. They give results indicative of the relative degree of purity of a sample of water when examined by a particular method, but there is no single method that gives more than that. By taking the methods together and considering the results which each individually furnishes, a trustworthy indication is obtained as to the quality of the water by chemical examination, but nothing more. Wanklyn's process furnishes a very useful result, and, in combination with the other method he used in connexion with it, results have been furnished upon which the greatest reliance can be placed, and they are the two best known to science, 16,235–9. He agrees with Dr. Dupré as to the purification of the Thames water by the dissolved oxygen contained in it, and he thinks the evidence with regard to the purifying action of oxygen is indisputable and complete, 16,240–3. There is no difficulty in detecting living organisms in abundance in the fresh suspended matter in river water by means of the microscope, but Dr. Sorby will give evidence on this point. The action of these organisms would no doubt be a purifying one upon water contaminated by dissolved organic matter by which they are nourished, 16,253–5. In order to obtain conclusive

SIR FREDERICK ABEL—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

evidence as to whether the Wanklyn process would be trustworthy when applied to samples of water which have been properly preserved in perfectly full bottles for several days after collection, he made a series of experiments. Some of the samples he took were kept for 14 days, and, so far as the proportions of free ammonia and albuminoid ammonia were concerned, they remained unchanged. Some of the samples were examined immediately, or within 24 hours, by the albuminoid ammonia process, part being filtered through an asbestos filter to deprive it of all impurity, and put aside for 14 days; the remainder being put aside also for the same time. In both cases the bottles were only three parts full. It was found that, allowing for a little loss of free ammonia in the filtering, there was but little diminution of free ammonia, and no important alteration in the albuminoid ammonia in the filtered sample; while in the unfiltered sample, in the bottles partly full, the free ammonia, in one instance had almost entirely, and in two instances had entirely, disappeared. This suspended matter, quite apart from the mineral matter, he considers has a purifying action upon the organic impurities, 16,256–9, 16,315–33, 16,365. He has inspected the river in 1878, 1880, 1881, and 1882, but especially in the summer of 1882. Except when he was in the sewage flow, he has on one occasion only been able to recognize at a distance from the sewage the distinct unmistakeable odour of the sewage, and then there was a strong and steady wind blowing from the outfalls. He was near Jenningtree Point about 1,000 or 1,200 yards from the outfalls shortly after high tide. In the flow it can be noticed from about 400 or 500 yards from the outfalls, but, when 50 to 100 yards from the flow, the smell becomes comparatively feeble, and you only get an occasional whiff, 16,260–9, 16,308–15. Before the time of the outfalls, the river between Woolwich and Westminster was frequently in a very offensive condition, and the odour, which he has seldom met with in late years in the neighbourhood of the outfalls, was a matter of by no means unfrequent occurrence between Westminster and Woolwich, 16,270. His house is in Woolwich Arsenal about 250 yards from the river, and his laboratory is about 180 yards distant from the river. During the 28 years he has lived there he has never experienced the least annoyance or inconvenience from the river, 16,271–4. The residents in the Arsenal suffer considerable annoyance from the smells which come from the large and increasing number of factories situated about the outfalls and up the river as far as the Victoria Docks. There are 14 manure works, some of them of the most offensive description, and there are 10 or 12 chemical works. In addition there are the Beckton Gas Works, from which they get smells occasionally. The smells are noticeable on Woolwich Common, and extend as far as Blackheath, 16,276. In 1866 he was directed by the War Office to enquire into the complaints that were made at that time of emanations from the factories that were growing up near the outfalls, and he found there was substantial cause for complaint in consequence of the careless manner in which those noxious trades were carried out. He was a member of the Noxious Vapours Commission which sat in 1877, and the whole of the evidence was very conclusive as to the very considerable extent the neighbourhood suffered from the emanations of the noxious vapours from those factories. No allusion was made to the outfalls contributing in the smallest degree to these nuisances, 16,277–83, 16,285–90. He has carefully examined the analytical results of the experiments made on both sides recently, and fails to see any evidence of an increasing pollution of the river. On the contrary, he feels confident that it has been well established that the river is competent to deal with the amount of impurity discharged into it, and that the purifying power at the present time is in excess of the polluting influences, 16,284. 16,291–300. The river, he believes, is capable of dealing with a very much greater degree of pollution than it does now. Within a particular and very limited area at certain times the river might become offensive in consequence of the presence of the sewage, but he has never found it to be so even in the hottest weather, 16,291–300. He believes that odours from the fish-manure works have been not unnaturally ascribed to the sewage, because the odour is something like, though much more intolerable than the emanations from excreta. He is convinced that in many instances, and certainly at Woolwich, smells of this description have been mistaken for smells emanating from the sewage outfalls. An "educated" nose can distinguish between the factory and sewage smells, but the "popular" nose would not be able to do so, 16,301–7. As regards the unfiltered sample of water, it contained both matter in suspension and matter in solution, and the disappearance of the free ammonia may have been due to animal *or* to vegetable organisms existing alive in the suspended matter. If the ammonia had been oxidised by the oxygen, it would have been equally oxidised in the filtered sample. He would not pretend to say that the organisms are diatoms and bacteria, but they probably are, 16316–33.

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—He received samples of mud taken from the river which were placed in the laboratory, where they became putrescent and emitted an unpleasant smell. This smell is characteristic of any mud which contains vegetable matter, or animal matter, but the latter is comparatively rare in muds, 16,231–4. There is no quantitative method for determining the actual amount of organic matter in muds, 16,237. There are some mineral matters in suspension in a polluted river which act upon certain classes of dissolved organic matter as precipitants, throwing them down in the form of insoluble materials, and, indeed, fixing them so that they undergo very gradual change afterwards and may be considered to be rendered practically permanent by this precipitation. There are also mineral matters which have the effect of fixing any sulphur compounds which are developed by the putrefactive decomposition of animal or vegetable matter containing sulphur, such as, for example, clays containing oxide or carbonate of iron. If by the putrefactive decomposition of the nitrogenous organic matter in suspension sulphuretted hydrogen be evolved, those iron compounds will fix the sulphur in the sulphuretted hydrogen, and will act equally upon some other sulphur compounds, producing sulphide of iron, which gives that black appearance to the mud, conveying to the uneducated mind a notion of filth and impurity which is erroneous, inasmuch as it is really due to a purifying action; and this would account for the black appearance of the mud deposits at Erith. The black mud becomes brown in appearance if it is exposed to the air, consequent upon the decomposition of the iron sulphide in the mud by the action of the air. Sulphide of lead would be black as well as sulphide of iron. The black sulphide has no smell, 16,244–50, 16,334–53. He has been unable to detect any smell in the mud at Erith, nor was there any smell coming from the gas bubbles in the mud, though he tested them, and the mud itself, for sulphuretted hydrogen. The gas he found consisted chiefly of marsh gas, 16,251–2, 16,354–7. The iron which turns the mud black comes from the mineral suspended matters which are continually washed about in the river and deposited on the saltings. The saltings do not turn black, because they have not the opportunity of being subjected to the process of being mixed up in a finely divided state with the sewage in the water, and thereby undergoing change as the sewage mud does, 16,334–341. Iron comes from the road detritus left by wheels and horse-shoes. The blackness of the mud at Erith is certainly not produced by the dark or black colour of the sewage, 16,342–51. No line can be drawn at which it can be said that a matter simply putrefies and does not oxidise, the oxidation proceeds concurrently with putrefaction. There are some animal substances which are more liable to putrefy than others, and some which would more readily oxidise if they were exposed to conditions favourable to oxidation. Given putrescible animal matter in mud, and expose it to the necessary temperature, such as a summer heat, it must of necessity putrefy, but oxidation will be going on at the same time, 16,361–4.

EFFECT UPON HEALTH IN THE NEIGHBOURHOOD OF THE MAIN OUTFALLS.—There are a number of official residents in Woolwich Arsenal, and although during the last 28 years there have been the usual visitations of sickness of one kind or another, there has not been a single case of sickness which could be ascribed even remotely to the outfalls, 16,275.

INJURY TO FISH.—The suffocation or poisoning of fish, as low down as Gravesend, he attributes to the effect of the sewage, which absorbs the oxygen in the river, so that there is not sufficient left to support the life of fish, 16,358–60.

## Dr. AUGUSTUS VOELCKER, F.R.S.,

Consulting Chemist to the Royal Agricultural Society of England.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He was with Mr. Dibdin on the 16th June 1883 when they saw an abominable nuisance arising from the slaughter-house refuse scattered all about the foreshore at Erith. He also counted no less than 14 sewers or sewage pipes that discharged their contents on the foreshore. This was quite enough to account for the complaints of nuisance from people who work in the mud and along the foreshore, and on this occasion it was so bad that Sir Frederick Bramwell who accompanied him, declined to proceed farther, and turned back, 16,366–9, 16,428–33. In the months of June, July, and August, 1882, he made several inspections of the river with Mr. Dibdin and Dr. Dupré, between Westminster and Purfleet. He found no bad smells arising from the river, except in the direct sewage stream when the smell was bad, but it gradually disappears, and at a distance of 600 or 700 yards, according to the state of the wind, it entirely disappears. Even when the water is shaken up there is only that faint smell which is perceptible all along the river from Westminster to Erith, 16,370–3, 16,422–7. The factories discharge a very large quantity of a most penetrating, disagreeable smelling vapour. At the London Manure Company's Works at Cubitt Town, from 40,000 to 50,000 tons of artificial manure are manufactured annually, and the smell produced upon the addition of sulphuric acid to some of the refuse material, such as blood or fish, is most obnoxious. It is not due to any ammoniacal emanations, but to the propionic, phocenic, and similar volatile fatty acids. The odours travel a long distance, and are perceptible three-quarters of a mile off up and down the river when the wind blows in the proper direction. Whenever he went down the river he did not smell the water, but he always smelt the factories, 16,374–5. In considering the comparative degree of purity of the Thames, he has taken account of the character of the suspended matter, whether it was more of a mineral nature, or of a combustible nature, the amount of oxygen consumed, and the amount of albumenoid ammonia found. The general conclusion he has arrived at is that which has been already stated by Dr. Dupré. In the most polluted Thames water he has invariably found nitrates present, not in the reservoirs, but within 1,000 yards of the outfalls, or in any part of the river where there is an abundant supply of oxygen. This shows that there is always plenty of oxygen to destroy the most obnoxious or most putrescible part of the organic matter. It cannot be denied that the discharge of so large a body of sewage from an outfall must create a local nuisance, say for 1,000 yards from the outwards, if so much; but it is remarkable how quickly this peculiar sewage smell is destroyed, and he is certain that people who are not intimately acquainted with the various smells, mistake certain animal emanations, such as those which come from the fish manure works, especially in a dilute condition, for sewage, 16,376–80, 16,411, 16,422–7. He agrees with Dr. Dupré and Sir Frederick Abel, that the dissolved oxygen to be found in the Thames water is more than sufficient to oxidise the polluted matter which is poured into it, and he also thinks that for giving comparative results, Wanklyn's method is the right one to employ, 16,381–2. He enumerates the various factories, on the banks of the river where artificial manure is manufactured very extensively, the smell from which is very offensive and remains so for a considerable distance. From the soap and oil works there is always a prevalent oily smell. The manure works smell most in the spring when there is a considerable pressure of business, 16,382–8, 16,397. From the ammonia and tar works there is always a strong smell, and when sulphate of ammonia is made sulphuretted hydrogen is given off, which is most unpleasant. On the 16th June last the smell of sulphuretted hydrogen from the Beckton Gasworks was very powerful. They are the most extensive sulphate of ammonia works in the kingdom, and manufacture about 30,000 tons a year. If great care were taken either to absorb or burn off the sulphuretted hydrogen, there would be no smell given off, 16,389–94. There is a good deal of gas lime produced at the gasworks also, which is an unsaleable commodity in that locality. Even the ordinary refuse lime from the Silvertown Soap Works has to be carried out to sea. Gas lime smells of sulphuretted hydrogen and gas and tarry matters, and the gas lime when exposed to the air gives off the sulphuretted hydrogen which creates a nuisance on the river as it is carried away in barges, 16,395–6, 16,414–17. From the fish manure factories most offensive odours arise, which travel a long distance, and produce the greatest nuisance. It is very persistent in its character, and is not easily oxidised. Upon several occasions he has smelt the fish factories at Erith. The two greatest offenders in this way are Mr. Johnson and Mr. Lang, 16,397–9, 16,418–21. Most of the factories he has mentioned are situated between Woolwich and Crossness, and others are close to Crossness. He is able to discern the difference between those smells and the sewage smells, 16,400–2. He is not prepared to say whether the sewage is at all purified on its way through the sewers, or in the reservoirs before it is discharged into the river. For agricultural purposes it would be just as good 40 miles from town as it would be five miles from town. It gets purified and may become almost innocuous, so as not to create any nuisance upon being applied to the land. Inodorous and clarified sewage is the better for irrigating purposes, and it would be better still if it could be filtered, because the suspended matter forms a crust upon the surface which is injurious to the vigorous growth of plants, which closes up the pores of the earth, 16,403–10, 16,412. The summer of last year was cold when he was inspecting the river, 16,426–7. When at Erith he noticed no sewage smell, and although he saw some sewage mud on the shore (at low tide) it did not smell, 16,430–33. He does not know the distance at which sewage farms as a rule are established from a town, though at Bedford the farm is close to the town, and is conducted without any nuisance to the inhabitants. There are paths running through the farm which are much frequented by people, 16,434–7.

## Professor WILLIAM ODLING, M.B, F.R.C.P., F.R.S.

Professor of Chemistry in the University of Oxford.

Scientific Evidence as to the foul State of the Water in the River near the Main Outfalls.—He has been acquainted with the Thames for 25 years, and has been very largely engaged in investigations as to its character during the years 1857, 1858, 1868, 1869, 1882 and 1883. He entirely concurs in the evidence of Dr. Dupré, and Sir F. Abel, 16,438–41. The self-purifying power of the river is in excess of the polluting action of the sewage discharged into it, so that even the worst stretch of water oscillating above and below the outfalls does not get so polluted as to be a nuisance. That fact has been established by ordinary observation of the river, because as a body of water it neither smells nor looks offensive, and there is no evidence to the senses that it is polluted. The analyses show that there is no definite body of polluted water which can be distinguished from the general mass of water, but that starting from Teddington, there is a gradual increase of pollution until you get to the outfalls, and then a gradual decrease of pollution till you get to Southend, when the water *qua* organic matter is in exactly the same position as it was at Teddington. The increase and decrease is perfectly continuous, and forms a curve, if the average of a number of observations be taken, 16,442–3. Taking the average of the three hot months in 1882 the water at Erith is such as might result from adding one part of average sewage to 27 parts of Teddington water, and at Purfleet it would be equal to 1 to 49 parts, 16,443. The reason he did not adopt the combustion process to ascertain the condition of the river was that the coarser method, that is Wanklyn's process, and the permanganate process, was better adapted for the purpose, 16,444–5, 16,549–53. He calls attention to Dr. Frankland's results, which show an excess of organic carbon at St. Paul's pier as compared with that at Erith, and that, at the time the samples of water were taken, there was no appreciable sewage in the water at St. Paul's. It follows, therefore, that there must have been a minus quanty of sewage at Erith. He thinks that the amount of organic carbon stated by Dr. Frankland to be at St. Paul's Pier, viz :—·503 parts in 100,000 parts does indicate the presence of sewage, although Dr. Frankland said it did not, 16,445–53. At no time does the pollution of the worst stretch of water become excessive; it is partly due to dilution, and partly to the destruction or oxidation of the sewage matter. Taking the normal proportion of oxygen in the water to be 1·84 cubic inches instead of 2 cubic inches, there are

PROFESSOR WILLIAM ODLING—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

several hundred tons of oxygen in the water over and above the quantity required to oxidise the sewage. According to his experiments the proportion of oxygen in the flood water at Erith is reduced to above one-fourth of its normal amount, three-fourths being expended in oxidising the sewage. This series of experiments was put in by Dr. Dupré in his evidence, 16,454–7. 16,572. The amount of oxygen in salt water is somewhat less than that in fresh water, but for the purpose of this inquiry it is practically the same. Taking the quantity of flood water passing Erith upon a single tide to be 3,200,000,000, cubic feet, that water actually contains 200 tons of oxygen which it has to expend; and having already expended 600 tons of oxyon it must have oxided several hundred tons of organic matter; 200 tons of oxygen sent up on the flood tide would suffice, at any rate, to oxidise over 100 tons of organic matter; and, as the quantity of organic matter discharged into the river at one tide does not exceed 50 tons, there is always more oxygen in the water than is required to oxidise the sewage, and that would account, in his opinion, for the sewage not creating a nuisance. There is enough oxygen left in the water to do the work over again, and, as the effect of that, the oxygen sometimes has been reduced to one-tenth of its normal quantity, 16,458-66, 16,555–71. He has no reason to suppose that sea water does not part with its oxygen as readily as fresh water for oxidising purposes, 16,467–70. There is no evidence to show how long the oxygen which has disappeared has taken in disappearing. The only facts known are that the fresh water coming down and the sea water coming up, each contain about two cubic inches of oxygen per gallon, and that the intermediate stretch of water contains only one-fourth of that quantity, and it shows that the organic matter is being destroyed faster than the water can fully saturate itself with oxygen. It has never yet happened that the amount of organic matter poured into the river has been so great that the water coming up has been inefficient to do its work, 16,471–8. He has considered Dr. Tidy's statement that the power of oxidation is diminished, when the amount of oxygen is diminished in the water, in a greater degree than in the proportion of the diminution of the quantity of oxygen. Sir F. Abel and Dr. Dupré are of opinion that it is not so: but he thinks there are some facts in favour of that theory and some facts which are opposed to it. He thinks that, with the reduction of the proportion of the oxygen, the oxidising power might be diminished in a somewhat more rapid ratio, which he attributes to the oxygen being more diluted, 16,479-81, 16,572. When the oxygen in the water is reduced very largely there is a continual tendency on the part of the water to recuperate itself from the air. Vegetation is an additional source of oxidation in the water, 16,482–4, 16,573-85. He wishes to call attention to those experiments of Dr. Frankland's, which are given in detail in the 6th Report of the Rivers Pollution Commission. Of the mixture of river water, and five per cent. of sewage, Dr. Frankland found that in two days 16 per cent. of the sewage matter had been destroyed; but Dr. Frankland put into the bottle from four to six times as much sewage as all the oxygen in the bottle could oxidise; therefore the amount destroyed was equivalent to 64 per cent. of what could be possibly oxidised. Dr. Frankland's experiments on the subject of oxidation seem to be of two kinds. They either prove nothing, or they prove the case for the Metropolitan Board of Works, and the instance he has just quoted belongs to the latter class, 16,485-90. In warm weather the smell given off by the discharge of the sewage stream is sometimes offensive and nauseating, but it does not spread very far. He has not been able to trace any substantial increase of disease to the smell from the river when, before the outfalls were opened, the sewage oscillated between Greenwich and Westminster and had an extreme stink, and the river was more black than brown. The volume of water in those days was not sufficient to oxidise the sewage, 16,491–7, 16,505–7, 16,589. If the sewage is discharged on the flood tide it might reach Woolwich in an offensive condition, but not otherwise. It might get into eddies and be unpleasant, 16.498-504. Since the outfalls have been in existence there has been no smell in the water above London Bridge, 16,505-6. The river does not get so well aërated in hot weather as in cold, 16,525. In 1865, he stated that the discharge of sewage at Barking would not be sufficient to purify the upper

PROFESSOR WILLIAM ODLING—*continued.*

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS—*continued.*

Thames. It has not affected the condition of things at Barking, but it has affected the condition of things in the upper river to which that question applied, 16,525–38. Twenty years ago he traced sea water as high up as Wandsworth, and he has said that where sea water went he believed sewage would go also, 16,539–41. He made one series of analyses by the organic carbon process to check the analyses of the other side, and they came out substantially the same. He took a minor part in Dr. Dupré's experiments in testing the oxygen process in salt water, but that is the only time he has tried it, 16,542–8. He believes that a running river like the Severn, with vegetation in it, and which is aërated by weirs, &c., would be more likely to dispose of sewage than a tidal river like the Thames, 16,588. He does not believe that sewage requires a long flow of river to be disposed of, and if Dr. Frankland said that, he does not agree with him, 16,585–6. He cannot speak definitely on the subject, but he thinks that if sewage is discharged into sea water in sufficient quantity to be putrefactive, it is probable that the nuisance would be greater than in fresh water. Sea water would retard putrefaction, but not oxidation, 16,590–1.

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—In a Report he made in 1858, as medical officer of health for Lambeth, he attributed the chief source of the smell in those worst times, to the large deposit of mud banks which existed in the river at that time, and were disturbed by the flow of the tide, causing considerable nuisance. He said then, that at whatever point the sewage was discharged, organic mud would be deposited on the exposed flat banks of the river, unless the scour of the river was increased. Substantially that is his opinion still, for the formation of the Thames Embankment has cleared out the upper part of the river, and the banks of mud at Lambeth are small compared to what they were in 1858, 16,507–20. The temperature of the mud banks, with the sun shining on them, is higher than that of the water, and the higher the temperature the more rapidly putrefactive change goes on. It is possible that under a hot sun the mud might reach the temperature of 120 degrees, but it was a slip either on his part or on that of the printer, if it is stated in the evidence of the Thames Embankment Commission that he gave that temperature as the regular heat of the mud, 16,521–4.

## MR. HENRY CLIFTON SORBY, LL.D., F.R.S.

SCIENTIFIC EVIDENCE AS TO THE FOUL STATE OF THE WATER IN THE RIVER NEAR THE MAIN OUTFALLS.—For 25 years he has devoted a great deal of attention to microscopic inquiries, especially in connexion with the structure of rocks, and loose deposits like mud and sand. Three years ago he began to investigate the mud and deposits which are to be found in the River Thames, and for this purpose he lived on board his yacht for a considerable time each year. He hands in the result of his investigations in the form of a report. (*See Appendix C.B.*), 16,592–7. He never found anything to complain of all the time he was on board his yacht as regards the river, nor did any of his crew. He used the river water for washing the decks, but not for cooking purposes, 16,598–600. There are a vast number of divisions included under the head of algœ, but those to which he has specially referred are the confervoid algœ, the desmid algœ, and the diatoms; and these he has united together in Diagram No. 1, 16,682-6.

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS.—For 25 years he has devoted a great deal of attention to microscopic inquiries, especially in connexion with the structure of rocks and loose deposits like mud and sand. Three years ago he began to investigate the mud and deposits which are to be found in the River Thames, and for this purpose he lived on board his yacht, for a considerable time each year. He hands in the result of his investigations in the form of a report. (*See Appendix C.B.*), 16,592–7. He collected a number of samples of water from Hammersmith to Gravesend, and allowed the suspended matter to deposit. That mud was then investigated by the microscope. Latterly he used an apparatus in the form of a very fine sieve, which retained all the suspended matter, 16,601–5. He

MR. HENRY CLIFTON SORBY—*continued.*

SCIENTIFIC EVIDENCE AS TO THE DEPOSIT AND ACCUMULATION OF FOUL MUD NEAR THE MAIN OUTFALLS—*continued.*

examined also the mud which had been recently deposited upon the surface, and found that it is materially different from the mud an inch or two below. At Erith he found a very large number of desmids and diatoms. These and conferva are well recognised plants which abound in the river, about which there can be no kind of doubt. They live in fresh or brackish water, 16,606–10. The brown colour of the mud is due to the countless thousands of desmids and diatoms. They do not like to be below the surface, and when collected in a glass beaker they can be seen to wriggle up to the top, where they multiply, 16,111–12. They contain a large amount of chlorophyll, and when exposed to the sun light they give off a considerable amount of oxygen. The yellow colouring matter they contain can be dissolved, and then by means of the spectrum-microscope they appear green, 16,613. He does not know whether the microscope has ever been employed in a definite manner to ascertain the quantity of sewage matter which was in the suspended matter of the water or in the mud, but by using that method in the case of the Crossness Bank he arrived at the same conclusion as the arbitrators did at the time of the mud inquiry, 16,614. He examined the matter in suspension to ascertain what were its special characteristics, and found it contained detritus from roads, horse droppings, and human fæces. The horse droppings contain a great number of the characteristic objects which are given by sewage, the most special feature being the hairs of oats. "A unit" of human fæces contains a large portion of undigested muscular tissue which is not in the condition in which it is found in roasted flesh; it has undergone such a process that it cannot be digested successfully by a warm acid solution of pepsine. These fibres also resist the action of dilute caustic potash. He determined the percentages of these substances all the way down the river. 16,615–20. These substances are not to be found in the pure mud of the Essex river, 16,621. The amount of human fæces is greater above Teddington Weir than in any part of the river below. From Teddington Weir the quantity increases to London Bridge, then decreases, and again runs up to another maximum between Barking Creek and Erith, and then decreases to the sea. The quantity of horse droppings increases to a very large maximum at London Bridge, it drops sharply to Blackwall, and then decreases regularly to Sheerness, 16,222–4, 16,716–23, 16,797–8. He was very much struck with the enormous number of excrements of minute crustaceans, mainly entomostraca. At page 13 he has given the number of those excrements which can be counted in a given unit weight of the mud. At Hammersmith it is sometimes as much as 1,100 in one-twentieth part of a grain, and the average number of such excrements in the surface water of the river is 166. At Erith in August, taking into consideration the entire depth of the river, the average number was 360, but in May it was only 240. He found that in summer when there was a large number of these excrements there was a much smaller quantity of the detritus of human fæces, but in winter, when these animals live to a very small extent, the detritus of human fæces existed to a much larger amount. At Greenhithe he collected a number of these entomostraca, and put in some human fæces with them, when they at once attacked it, and he saw them eating it. He believes that the maximum number in the summer would be about 25 per gallon, and that as a grain of human excrement contains parts which they can neither eat nor digest, there would not be more than $\frac{1}{20}$th of a grain per gallon for 25 to feed upon. Small as these little creatures are, he feels sure they play a most important part in the destruction of the sewage, 16,625–29, 16,634–5, 16,681, 16,701–8, 16,726–36, 16,785–8. The anellids and other mud-worms perform the same function in the water as the earth-worms do upon the land. He has collected mud in glass beakers and watched these mud-worms wriggle through it, and he has no doubt that their nutriment is the mud which they swallow and eject, utilizing the organic matter present, 16,630–2. His experiments were made at half-ebb and half-flood, and as a general rule there is much more mud held in suspension near the bottom than near the surface, and there is a different distribution of the constituents, 16,633. He found that on the average the amount of sewage material carried up on the flood-tide was 40 per cent. of that carried down by the ebb-tide, and that at spring-tide only 24 per cent. was carried up of that carried down. He produces samples of materials which would not pass through a strainer with apertures of one two-hundredth part of an inch in diameter. All the normal mud would pass through, 16,636, 16,761–81. By means of the microscope he was able to determine between quartz sand and flint sand in the mud. The sand of the sewage contains about 14 per cent. of flint, but the old sand that was deposited to form the saltings contains only one per cent. of the flint, and that enabled him to determine approximately the amount of sand derivable from sewage, which is now contained in the mud deposited at Erith. He produces samples of sand from the drift, from the sewage, from Coalhouse Point, from the saltings, and from the banks at Erith, 16,637–40. The sand in the mud banks at Erith is exactly the same sand as that which is found in the old saltings in the bed of the river, and differs considerably from the sand in the sewage, 16,641–4. He finds, in conclusion, that the quantitative method he has employed is far more accurate than is requisite for the purpose, as it has enabled him to obtain an idea of the character of the contamination in various parts of the river, a large portion of which are removed, especially in summer, by the action of minute animals, and that the combined effect of these, and of the large volume of water in the river near the main outfalls, is to rapidly reduce the percentage of sewage in the mud and in the water to considerably less than what it is above the outfalls. He produces a diagram illustrating this. He believes that the greater amount of impurity near London Bridge is not due to material drifted up from the outfalls, 16,645–61, 16,717–23. The constituents of the mud, say at Erith, are composed of clay and shale deposits, the material produced by the decomposition of feltspar, organic matter, diatoms, &c. Four per cent. of this is composed of the indestructible part of ordinary sewage which is innocuous, and one per cent. of the destructible, or detritus from human fæces, 16,662–72, 16,680, 16,687–92, 16,789. The smell would be very small. He never smelt the mud at Erith, and the only nuisance he experienced while living there was from the coal dust at Messrs. Beadle Brothers' Coal Wharf. His men all laughed at the smell of the river, but they complained of the smell from the factories. 16,673–79. There are a vast number of divisions included under the head of algœ, but those to which he has specially referred are the confervoid algœ, the desmid algœ, and the diatoms. These he has classed together in his Diagram No. 1, 16,682–6. In estimating the number of fragments in an unit volume of material he has counted all those about which there can be no possible doubt, but those which he cannot completely prove to be derived from muscle, fæces, or any other material, as the case may be, he has only counted half. This gives a fair result, and is similar to the principle adopted in counting the corpuscules of blood, 16,693–700. He explains the method by which he prepared his specimens for the microscope. The accuracy with which the proper quantity is taken up each time for the glasses, and the success of the method depends on the skill of the operator, but from constant practice he is able to do it now in a manner which astonishes him, 16,701–8. Gallon per gallon the river is worse at London Bridge than at Barking, and Diagram No. 5 shows this, 16,717–23. He agrees with Dr. Tidy that spirals are developed from green vegetable food, but a large number are found in the road drift which have come from the excrement of horses, 16,724–5. The entomostraca abound in the sea, in river streams, where there is neither sewage matter nor muscle, and possibly they are to be found in well water, 16,726–36. The increase in the number of algœ at Barking as distinguished from Woolwich is partly due to the fact that they belong to the class which live better in brackish water. They are different to those which are found at London Bridge, and are larger. The carbonic acid in the river water near the outfalls enables them to grow more rapidly than they can do in pure water, 16,737–46. Samples of sewage were taken at Crossness as well as at Barking, but as the latter is a stronger and a richer sewage than at Crossness he has only mentioned Barking in his tables, 16,747–51. Immediately above Teddington Weir the water contains 32 per cent. of oat hairs and 28 per cent.

## Mr. HENRY CLIFTON SORBY—*continued.*

Scientific Evidence as to the Deposit and Accumulation of Foul Mud near the Main Outfalls—*cont.*

of muscle fibres. Immediately below the Weir the muscle fibre falls to 10 per cent. because it is diluted with a larger amount of mineral matter, and there was a larger amount of mud per gallon, because that mud is stirred up by the fall over the river. The mud is worse at Teddington than at Barking Creek, but the water itself is not, 16,752–69. The chemical gentlemen who have given evidence have entirely overlooked the action of the algœ on the mud. They increase most rapidly, and it is stated that one of these Cyclops can, in a year, if they all survive, give rise to 4,000,000,000, if the conditions are favourable and they have abundance of food, 16,787–8. The Cyclops are visible to the naked eye, and are about one-sixteenth of an inch in length; some are larger. At Crossness there are a greater number of Daphnes, which are larger than the Cyclops. The cause of their death is their being drifted into water which is too salt for them, 16,790–6.

## Mr. HUGH HERBERT MASON, M.R.C.S., L.S.A. San. Sc. Cert. Camb.

Medical Officer of Health for East Ham.

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls.—He has held his present appointment since 1877, 16,801 He has not noticed any smell from the sewage in the river at Barking or at East Ham, but he has smelt the sewage as it is discharged from the outfall, and he has noticed the smells from the factories. At high-water he has never noticed any indication of sewage at Barking, 16,833–7. He observed nothing unusual in the appearance of the bodies which were brought ashore after the "Princess Alice" accident, nor was there anything different in the state of their clothes to that of people drowned elsewhere, 16,838–44. He saw about 30 of those who landed alive. They were suffering only from the effects of their immersion, and not from sewage poisoning. He has seen people suffering from zymotic diseases caused by sewer gas, and he has seen cases of poisoning by sulphuretted hydrogen. This produces a comatose condition previous to death or recovery, 16,845–53, 16,890–2, 16,914–15. He has occasionally been able to distinguish the sewage smell from the factories smell, but he has not paid much attention to the subject, as his duties do not often take him near the river, 16,880–2. He has never seen, nor has he ever heard of a case of death from drowning being accelerated by the presence of sewage in the river, 16,883–9, 16,898. Drowning is suffocation, and one symptom is that froth exudes a little at the mouth, 16,893–7. He saw some of the bodies which were not recovered for some time after the accident, but he did not notice that they decomposed more rapidly than other bodies which had been drowned elsewhere in the Thames, or in an

## Mr. HUGH HERBERT MASON—*continued.*

Scientific Evidence as to the Foul State of the Water in the River near the Main Outfalls—*continued.*

ordinary pure river. The existence of sewage would rather manifest itself in those who recovered than in those who were drowned, if there were any deleterious matters given off from the sewage. He saw no cases of retarded recovery, 16,899–905. His district is not entirely a riverine district. A part of Kent intervenes, in which the outfall is situated, 16,906–8.

Effect upon Health in the Neighbourhood of the Main Outfalls.—The district of East Ham includes that portion of the town of North Woolwich which is not in the County of Kent, and it extends back from the river for about three miles, 16,800–4. The health of the whole district is about the average of England, and there is no difference berween the health of the riverside population and the rest of the district. It is not specially subject to zymotic or other diseases which might be attributed to emanations from the river, 16,805–9. His private practice is in a different area to his official district, which is bounded by the eastern side of Barking Creek, 16,810–13. The employés of Lawes' Chemical Works live in about 50 cottages at the mouth of the creek, and as medical attendant to their club he finds their health is about the average. Zymotic diseases have not been prevalent amongst them, and there has been no typhoid fever, or diphtheria. The epidemic of scarlet fever in 1881 did not extend more beyond the riverside district than in other parts, 16,814–27. The population on the banks of Barking Creek is a low class labouring population. They are not more unhealthy than people of a similar class living elsewhere. He has not been able to trace any illnesses there to emanations from the creek, 16,828–32. He lives about a mile and a half from the river, and there are about 9,000 people living in his district. There was an outbreak of scarlet fever in the district in 1875, but he was not officially connected with the district at that time. There was a very high zymotic death rate all over the district and West Ham, which extended also into the country. It was supposed that the fever came down to Barking from London, 16,854–72. In 1879 and 1880 scarlet fever and diarrhœa were prevalent, and the zymotic death rate was high at that time, 16,873–77. Barking contains a good many cesspools, but there is a sewer there. The water supply is from the Grays Works, and nearly all the people obtain their water from that source now, though they did not at the time when there was so much sickness, 16,909–13. The Beckton Gasworks are in his district, and the men are healthy for their class, and considering the way they live, 16,916–7. The houses, in which the men employed at Lawes' Factory inhabit, are situated about 20 yards from the river wall, and the factory is almost on the bank of the river, 300 yards below the outfall. The population of these houses is about 200 including women and children, 16,918–20, 16,826.

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